BACILLARY DYSENTERY

IN

NORTH WEST EUROPE

CLINICAL SURVEY AND BACTERIOLOGICAL STUDY

By

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PART I.

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BACILLARY DYSENTERY.

Definition.

An inflammatory disease, primarily of the large intestine, characterised by acute onset with general malaise and diarrhoea of varying severity, the frequent fluid stools, which are accompanied by abdominal pain, griping and tenesmus, containing at some stage of the illness inflammatory products from the intestinal mucosa. It is a contagious disease occurring in sporadic, endemic and epidemic form and is caused by two main types of micro-organism.

History and Geographical Distribution.

Dysentery has been regarded throughout the ages as the especial scourge of armies in the field and in this respect it has maintained its reputation during the present world-war, - a reputation which in this case it has not even shared - or but to a small extent - with its former rival for precedence - enteric fever. In all the great European wars from the Hundred Years' War downwards, history records the powerful influence which this disease has exercised on the prosecution of a campaign. After the Battle of

Agincourt in 1415 the English Army had to be repatriated from France as it had lost three-fourths of its effectives from this disease alone. In more recent times, as, for instance, during the Russo-Turkish War, a morbidity of 57.75 and a mortality of 16.11 per 1000 are recorded among the Army of the Danube, while in the Army of the Caucasus the morbidity was as high as 90 per 1000. And though epidemics on the Western Front in this present War have not been attended by the same high mortality as is recorded of similar epidemics in the past, yet history will probably record a very considerable mortality from this disease in the other theatres of war. Ascoli records 7076 deaths in 1917 in Prussia among 58,176 cases of the disease.

While dysentery has been regarded as ranking next in importance to malaria in the Tropics, the pure bacillary form of the disease is more peculiarly associated with temperate and cold climates, though it is encountered in endemic and epidemic form in practically every country in the world and in each case it usually attains its maximum of severity during the warmer months of the year.

The term dysentery has been used in literature to denote a symptom complex which indicates an inflammatory or ulcerative colitis, but it is only in comparatively recent times that the causal agents have been found and defined.

Losch in 1875 disdovered the entamoeba histolytica in the stools of dysenteric patients and Kartulis elaborated this work, describing the characters of the entamoeba, its presence in the liver abscesses associated with this type of the disease, and its absence from the stools of normal persons. There then ensued a controversy as to whether all cases of dysentery were amoebic in origin, a proposition which was stoutly opposed by Lutz in Germany and Councilman in America. But, though Chantemesse and Widal in 1888 isolated from the stools of dysenteric patients a gram-negative bacillus which they differentiated from the Bacillus Coli and with which they produced experimental dysentery in animals, it was not until 1898 that Shiga in Japan, and in 1900 Kruse in Westphalia demonstrated conclusively the causal relationship of what is now known as the Shiga-Kruse bacillus to the cases of dysentery occurring in these countries.

Thereafter Flexner in 1900 isolated from cases of dysentery in Manilla a bacillus, which is now named after him, which differed from Shiga's bacillus in fermentative reactions; Strong, working in the Philippines, isolated a similar strain which had secondary fermentative characteristics, and in 1903, Hiss and Russell added yet another strain to this group - B.Dysenteriae 'Y' -

which differed from the two preceding strains in fermentative reactions. Different investigators have, from time to time, added to this group strains, isolated from local epidemics, which have differed slightly in their fermentative or serological reactions and it is now come to be generally recognised that the group is a large one and includes many strains which can be separated by serological methods, though there is considerable overlapping in the other characteristics of the different members. The distinguishing characteristic of the group is that they all ferment glucose and mannite and they are now usually known as the Flexner-Y Group. Their relation to the disease has been proved by animal and human experiment and the designation 'acid type' applied on account of their fermentation of mannite as well as glucose, has now fallen into disuse, while the designation 'non-toxic', or 'pseudo-dysenteric type' applied by Kruse, who noted that the disease produced by them was of a milder nature than that caused by the Shiga bacillus, has now been given up, though it still appears occasionally in German literature on the subject.

Etiology.

While overcrowding and defective sanitation favour the spread of the disease, and insufficient food, dietetic

derangements, cold, exposure and fatigue render the individual more susceptible to the infection, the sole determining cause of the disease is the dysentery bacillus, which, having gained entrance to the alimentary system, pursues its activities in the mucous membrane of the large intestine, whence it is excreted in large numbers in the early alvine evacuations which are thus the important and essential factor in the further spread of the disease.

All races, all ages, both sexes, the robust and the weak are equally liable to the disease, though children and newcomers are more readily infected in districts or in communities where it is endemic.

Endemic in the Tropics and in several if not most countries in the Cold and Temperate Zones, it becomes epidemic under suitable conditions. Epidemics had greatly decreased in frequency prior to the War which, as pointed out by Kathe, has discovered the presence of endemic dysentery in Germany to a much wider extent than was formerly realised and has led to wide-spread epidemics among the civil and the military populations. In England, the disease had been regarded as confined to small outbreaks in certain Asylums - an experience common also in America - but the B.Dysenteriae has not been accepted in England as contributing to the 'Summer Diarrhoea' of children, though Duval and other

observers have demonstrated its presence in many cases of this disease among children in America. In 1915 the German Army suffered a severe epidemic in Galicia and similar outbreaks are reported among them from time to time since that date, both on the Eastern and on the Western Fronts. Gallipoli has furnished us with a very considerable number of cases and in Egypt and Mesopotamia, East and West Africa, Salonica and Italy, the same story is repeated. The earlier outbreaks among the German Armies on the Eastern Front were mainly due to B.Dysenteriae Shigae, while those affecting the Allied Armies in the West have been chiefly due to the Flexner-Y group; but in any one epidemic, it is quite customary to find both types of bacilli associated, though the primary outbreak may have been shown to be due to one type only.

Dysentery is endemic in parts of France, e.g. in Brittany, the Basse Somme, Champagne and Eastern France, and the disease first appeared in the French Army after the Battle of the Marne in 1914 and though sporadic cases were occurring among British troops from time to time, the first serious epidemic of the disease occurred in 1916 during the Battle of the Somme and it is largely from a study of these cases in the field and later at a Base Hospital, that these clinical observations have been made, while the Bacteriological work has been carried out partly at a Base Hospital in 1917 and

partly in a Field Laboratory in the Somme Area in 1918.

Epidemiology.

Bacillary dysentery is a contagious disease and is communicated from the sick to the healthy by direct or indirect contact. The virus contained in the dejecta from the infected person gains access to the next host in a number of ways, the route of infection being always the same, viz. by the mouth to the gastro-intestinal tract.

Epidemics, which occur from time to time among communities where the disease is endemic, are attributable to defective sanitation, using that term in its widest sense, individual and communal. Where, as in the Armies, improvised latrines are used by large numbers of men, it is easily seen how the disease spreads by direct contact. The healthy subject who uses the same seat as an infected case in its early stage, gets his hands soiled and as an elaborate toilet is a luxury unknown under the conditions of active warfare, these hands convey infection directly to his mouth, or indirectly by means of his cigarette or his food. And in the trenches, where, with all the best efforts at prevention, and co-operation by all concerned, the soil is probably heavily infected, infection can the more readily spread in the same way.

Probably the most important agent in the direct or

indirect spread of the disease is the mild ambulant case, which is so frequently regarded as a simple diarrhoea, and if a soldier remains at duty with his unit, or if a civilian continues at his daily avocation. Some statistical support is given to this view by the following figures for part of the 1918 epidemic in the Somme Area. When, at the height of the epidemic, the admissions to Hospital became so great that bacteriological examination of all cases was impossible, it was decided to evacuate all cases with definite clinical evidence of the disease, and to concentrate on the examination of doubtful cases and the so-called diarrhoeas. Specimens taken by means of a rectal swab were examined from 1513 cases of this category, three examinations, on successive days, being made in each case and by this means the presence of 298 cases or 19% of bacillary dysentery was discovered in this group. It is interesting to note here that of these 298 positive findings, 15 were due to Shiga's bacillus, which has not been common among cases in France, and which is usually regarded as causing the more severe form of the disease. Spread of infection in a unit usually occurs in the following manner: with the advent of warm weather in May or June, sporadic cases of diarrhoea, mild in type and regarded as seasonal, appear among the troops. These usually respond to simple medicinal treatment, make a speedy recovery and return to duty. But

the number of such cases increases daily and among them - frequently in the young men who have been recently drafted into a fighting unit - occur some cases of a more severe nature, which are necessarily evacuated and shortly afterwards reported as true bacillary dysentery. In the meantime the disease has established itself endemically, at least in that unit, and it will continue to be a fruitful source of trouble for the rest of that season and liable at any time to assume epidemic proportions. In all big epidemics of dysentery in Armies, diarrhoeal diseases of a mild nature are concurrently increased and, if they are investigated, a large proportion of them will be found to be true dysentery. These cases are important because they are so often overlooked and they are so potent of evil because they are so mobile.

Where the disease is not endemic, however, the survival of the infecting bacillary agents from one epidemic period to the next, has to be sought elsewhere. Carriers are immediately suggested as the most likely solution and the work of several investigators has given presumptive support to this view, though epidemics have not been definitely traced to carriers in the same conclusive way as they have been in the case of enteric fever. But the dysentery carrier differs from the typhoid carrier in that in the former disease it is unusual to find the bacilli in large numbers in the stools for any

length of time after the acute phase of the illness and it is more probable that in dysentery the bacilli are excreted in large numbers only during or immediately after a mild diarrhoeic attack in a subject who has previously had the disease. The bacilli penetrate deeply into the wall of the colon and have been recovered post mortem in the course of this work from the subserous coat of the intestine and also from the inflamed mesenteric glands in cases from which no dysentery bacilli were recovered before death. It seems reasonable to suppose that a dietetic derangement would serve to light up temporarily an old quiescent infection of this nature, which would prove to be the focus for the epidemic spread of the disease. This has been borne out by experience in the Field with a unit, which, having sustained dysentery in France, was transferred immediately afterwards to the Italian Front in the winter of 1917, the effective strength having been made up by the early return from hospital of several cases of bacillary dysentery, most of whom under the rigours of a cold climate and a restricted dietary which gave rise to gastro-intestinal derangement developed a recurrent diarrhoea of short duration and with typical stools which were again found to contain the dysentery bacilli. The literature on the subject of carriers in

dysentery is very fully summarised by Ledingham and Arkwright, who record the finding by Simon in 1910 from the stools of men who were known to have had the disease of dysentery bacilli up to a maximum of 618 days from the date of the original attack. Mayer has also described the occurrence in a regiment infected with dysentery, of healthy carriers who, though harbouring the bacilli for a short time, were not themselves affected by the disease at that time or subsequently. Ledingham, while looking for typhoid carriers in England, discovered genuine dysentery bacilli in subjects who had never been abroad, and during the War Glynn has reported[2] positive findings among 504 healthy recruits and the presence of Shiga's bacillus in an old woman who suffered from chronic diarrhoea. There has been little need to seek for carriers to explain the survival of infection in the Army from one period to the next, as sporadic cases have continued to occur during the winter months and indeed in some units the disease has prevailed in epidemic form during the coldest months of the year. During the course of this work bacilli of the Flexner-Y group have been recovered from subjects of the disease up to a maximum of six weeks from the commencement of the illness but work among convalescents did not come within the scope of this investigation. Rajchman and Western, however, have reported

the finding of B. Dysenteriae Shiga up to twenty four weeks after the onset of the disease in convalescents from the Mediterranean.

Vincent has recorded two interesting epidemics in the French Army, one in 1890 at Chalons which is attributed to the pitching of tents over the cesspits of the previous year's camp in which dysentery had been epidemic, the other in a camp near Algiers, where dysentery had prevailed the previous year and to which a Battery of Artillery were sent in 1894; a violent sandstorm which lasted for a week coincided with the arrival of these troops who complained that sand and dust were present in all their food and drink - an epidemic affecting 15% of their effectives immediately followed.

Though they are not common, explosive outbreaks which cannot be explained by infection from a carrier do occur from time to time, suggesting an infected food or water supply. Umber records such an outbreak among his hospital staff for the spread of which some common article of food was suspected though not proven to be the direct cause; and the following epidemic, which I have experienced, suggested an infected water supply, not a common or generally accepted occurrence. A unit which had been engaged from 1st October to 11th November in the fighting for the Passchendaele Ridge in 1917 was withdrawn from the line and after a few days'

rest moved by rail to a village near the coast. A few cases of dysentery had been observed during the interval between the trench warfare and the transference by rail but these were evacuated and the diarrhoea rate in the unit reduced to nil. Two to four days after arrival in the new area some 15% of the unit were affected with diarrhoea and a number evacuated and found to be genuine bacillary dysentery. Some common cause was sought for as a carrier could hardly account for such an explosive outbreak. Rations were wholesome and the cookhouse staff suffered as severely and at the same time as the rest of the unit. It was found that the approved water supply, which was duly labelled, was recommended to be drawn from an open stream where it crossed the main road. The village had just been vacated by a unit notorious for its dysentery and recent gross human pollution of the banks of the stream above the filling point were not far to seek. The small amount of chlorine recommended for use in the water carts was quite insufficient to meet the well-known fluctuating requirements in wet weather of an open running stream which was invaded by ducks, etc. and as the cookhouse stood practically on the banks of the stream, the washing of cooking utensils in untreated water was a moral certainty. All cases were immediately segregated, and treated, the water supply had already been condemned and a satisfactory supply inaugurated at

the source of the stream, and the whole epidemic was over in a week. The weather was cold - there were no flies in evidence - the men were much more comfortable and better fed than they had been for weeks, the surroundings of the stream were low and damp, conditions which according to Vincent render the survival of the bacillus possible for 20-30 days! dysentery or diarrhoea had not been prevalent in the unit: they had had three to five days in which to incubate an infection obtained elsewhere (the incubation period is probably less than five days): the explosive nature of the outbreak and its immediate cessation when a pure water supply was obtained all point to the probability that the epidemic was waterborne.

Shell hole water has frequently been incriminated and though dysentery bacilli have not been recovered from this source there is usually ample possibility for its pollution and the relation of gastroenteritis and diarrhoea to the drinking of shell hole water is undoubted. An explosive outbreak of gastroenteritis and diarrhoea occurred in one company of a Battalion to which I was attached while they were holding the front line trenches, the other companies being unaffected. The weather was very hot at the time, early summer of 1915; the men, newly arrived from England, had not realised what water discipline meant and, their own supplies exhausted,

they soon found water by digging down a few feet in the clay of French Flanders. Many of the men had acute vomiting, all of them had diarrhoea and I found they had all drunk water from a surface "well" sunk within a few feet of the graves of British and German troops! It is not suggested that these were cases of true bacillary dysentery as all but two of them quickly recovered and no bacteriological examination was made, but I have come across two cases of genuine bacillary dysentery - one in an officer, the other in a man who related the sudden and acute onset of the disease within thirty-six hours of their drinking shell hole water during hot summer weather.

Wherever sanitation is in any way defective, there flies abound in the warmer weather and they are generally accepted as instrumental in the indirect spread of the disease, carrying the bacilli from infected fæcal deposits to the food to which they are always attracted. The summit of the epidemic curve of bacillary dysentery is reached in the months of August and September when flies are most abundant but the disease also prevails in epidemic form in cold weather, as, for instance, during the coldest weather in the Crimean War; and I have had experience of a similar epidemic among German prisoners during the winter 1918-1919 while keen frost prevailed and snow lay on the ground.

Langstein, Somerfeld and Baginsky emphasise the importance of children in the spread of this disease as in the case of enteric fever. The mild cases are again the source of trouble:- 60-70% of the children under two years of age who were admitted to Langstein's wards were found to be suffering from bacillary dysentery.

Domestic animals have also been incriminated for the spread of the disease - the dog has been known to have it, Firth induced it experimentally in a monkey, and it is known to affect this animal in nature.

Infection by contact, probably as the result of the neglect of precautionary measures of toilet, occurs from time to time and I have seen cases occur among medical officers, nursing orderlies and a padre in hospitals where dysentery was treated and also two cases of infection among laboratory attendants.

And as the introduction of dysentery into Germany as an endemic disease has been attributed to the return of infected armies from the Franco-Prussian War of 1870 when the disease was very prevalent, so it is possible and even highly probable that we shall have to reckon with the appearance of this disease in something approaching epidemic proportions among the civil population at home,

introduced by the infected soldier who returns to civil life. And in this connection it were well that special attention should be paid to the investigation of summer diarrhoea in children who may contract true bacillary dysentery from their soldier parent.

Symptomatology.

The incubation period is probably two to five days, though Strong and Musgrave who produced the disease in a condemned criminal by the ingestion of a living culture, place it at forty-eight hours. There is frequently a very short invasion period, when the patient has a vague sense of abdominal discomfort, which is speedily followed by a disease acute in onset and characterised by general malaise, with pains in the legs, the back, and the abdomen; headache, loss of appetite and a feeling of nausea which in several cases results in actual and sometimes in severe vomiting. The temperature, frequently undisturbed, seldom rises above 101° or 102° F. and is as a rule only sustained for from one to five days. Diarrhoea manifests itself early and the stools, at first abundant and watery, alter in character as they increase in frequency, the initial faeculent stools giving place to mucoid, mucopurulent and sanguinolent evacuations,

the blood being dotted, streaked or closely incorporated in the mucus. Griping is almost constant, or is very easily excited, tenesmus is severe, the call to stool almost incessant until ultimately the patient cannot leave the stool, or sphincter control is lost and the dejecta are voided on to pads of cotton wool or tow. The character of the stools should be particularly noted in all cases, from the very beginning of the illness, as in the mildest primary and in the shortest recurrent cases, mucopus or mucopus and blood will be detected in some of the stools passed during the first few days, especially if microscopic examination be resorted to. This examination is also most helpful in prognosis and in the control of dietetic and general treatment.

There exists a diarrhoeal facies which can be observed in even mild cases if they are seen on the first day of illness, when this sign is helpful in differentiating true diarrhoeas from malingerers. The expression is anxious and the face is 'pinched', a condition more easily recognised by experience than defined in a few words, for contraction and pallor of the tissues of the cheek and nose do not adequately describe it. The skin of the body generally becomes dry and atrophic to the

touch. In a few cases where on clinical, serological, and bacteriological grounds typhoid fever as a concomitant was negatived, I have observed in genuine bacillary dysentery a rash much resembling that of Rose Measles, appear about the tenth day of illness. It was most marked in the skin over the splenic and hepatic areas, and to a less extent on the back and the abdomen. These spots are of the same size as, but are lighter in colour and apparently more superficially placed in the texture of the skin than are the true rose spots of enteric fever and as a rule they are erythematous rather than petechial. Since making this observation I have discovered an account by Schultz (1917) of a rash in dysentery resembling that of typhus fever.

The tongue, thickly coated with a white fur at the beginning of the disease, quickly cleans and becomes bright red and rather dry in cases that progress to early recovery, but in the more severe cases that assume a typhoid aspect, the tongue remains furred and becomes very dry and fissured. The temperature, already referred to, is not in itself of much note, as it is frequently normal or subnormal in cases of quite moderate severity while in severe cases it seldom rises above 101° or 102° F. and only remains elevated for one to five days or thereby

while in a few cases, rare in temperate climates but more common in the Tropics, of choleraic dysentery, the patient passes into a state of hypothermia and dies. The pulse is slow - 70 to 90 per minute - even in cases with elevated temperature. It is soft and compressible but not dicrotic though the blood pressure is usually low, 70-90 mm. diastolic and 100-120 mm. systolic. When the pulse rate accelerates and its quality degenerates, the possibility of suprarenal insufficiency should be entertained - a condition which has been fully borne out by postmortem examination of these acute cases.

Apart from old-standing disease, intercurrent affections, or complications, the lungs are not usually involved and indeed at autopsy it is often remarkable how free from oedema they usually are in subjects who have been ill and bedridden for three weeks or more. This is probably accounted for by the dehydration of the tissues which is such a marked feature in these cases. The abdomen, flat and retracted, is tender to pressure, especially over the sigmoid flexure - a feature of note in the mildest cases. As a rule, however, tenderness to pressure is elicited over the colon in the whole of its length but is most marked

at the flexures. The spleen is not palpable and is found postmortem to be very small in the great majority of cases. The liver may be slightly enlarged from venous congestion but there are no liver symptoms such as are found in cases of amoebic dysentery. After a few days' illness the colon, thickened, oedematous and tender, can be felt in practically its whole length and rolled under the fingers. Vomiting is frequently a troublesome feature in the early days of the more severe cases and it may be so severe as to necessitate the temporary interruption of oral alimentation as the provocation of vomiting gives rise to great discomfort from griping and tenesmus and to increased frequency of the call to stool. In the more severe cases too, hiccough is met with and sleeplessness may call for medicinal treatment. The urine, which is occasionally retained, especially in the terminal phases of acute cases, is scanty, dark in colour, and contains a small amount of albumen. In the more severe cases great thirst is complained of.

Estimation of the leucocytes has been carried out in a series of cases representing the various clinical types of the disease. In the ambulant cases the number is normal or very slightly raised, in moderately severe

cases it rises to 10,000 or 12,000 per cubic millimetre,while in severe and grave cases with marked dehydration of the tissues, it has been found to be 17,000 to 20,000 per cubic millimetre, while some observers have reported counts of 25,000. No information of value has been obtained from a series of differential counts conducted concurrently with the ordinary estimation by the Thoma-Zeiss method, as the variations from the normal proportions in the case of the different cellular constituents were so small as to be accounted for by personal error - in some cases the polymorphs, in others the lymphocytes were relatively increased. When dehydration of the tissues is eliminated, the leucocytosis quickly falls to normal or subnormal.

Clinical types of the disease.

Clinical types merely reflect the severity or otherwise of the disease which is the same in all its forms. Ambulant cases, mild cases, moderately severe cases, severe and grave cases will embrace most of the types met with and under severe and grave types are included the acute fulminating, the diphtheritic, the gangrenous, the typhoid and the choleraic forms, while the chronic, the relapsing and the recurrent forms are

self-explanatory. The ambulant case may have a diarrhoea, which is regarded as simple and seasonal, and which lasts for one day only, some three to five stools having been passed in the twentyfour hours. Mild cases usually last from three to five days, provided the subsequent dietary is regulated. Moderately severe cases with ten to fifteen stools in the twentyfour hours, usually run their course under suitable treatment in seven to fourteen days, while severe cases may run into a protracted convalescence which lasts for months. The acute fulminating case of which I have seen four, may die of toxaemia within four days, the diphtheritic and gangrenous types are so named from the sloughs which are found in the stools, the choleraic type has not been met with here but several cases with a typhoid aspect have been encountered and in some twenty of the more severe cases blood culture was carried out, usually on the second to the fifth day of illness, but in no case have dysentery bacilli been recovered from the blood during life or after death. A case has been described by Maer in which the symptoms were those of an acute general toxaemia, abdominal symptoms being absent, and Bacillus Dysenteriae Shiga was isolated from the blood.

Most of the above types may become chronic or recurrent if early and effective treatment is not instituted.

Hart has described a type of dysentery in healthy recruits where there is merely acute hyperaemia and diffuse swelling of the intestinal mucosa. These run a rapid course and terminate in coma and convulsions, and postmortem there are found small subserous haemorrhages and oedema of the brain. I have met with six cases of this type of the disease, but all of them were in emaciated subjects and death was preceded by violent muscular cramps culminating in convulsions and coma. Postmortem examination of these cases revealed the presence of what would be regarded as an early dysenteric infection of the colon - hyperaemia, superficial excoriations, or deeper ulceration and necrosis of the mucosa of the sigmoid flexure, with hyperaemia of the stomach and part of the jejunum and ileum. Few subserous haemorrhages were found but in all six there was marked oedema of the brain, a large collection of clear sterile serous fluid lying between the dura and the pia-arachnoid which latter was oedematous over the cortical convolutions and the cerebellum but normal over the base of the brain. In these cases there was no excess of fluid in the ventricles of the brain and there was marked venous

congestion over the pons and the medulla and oedema of the white and grey matter of the brain.

Complications and sequelae.

In the milder forms of the disease, complications are infrequent and rarely severe and the development of sequelae from all types of the disease largely depends upon the early and successful treatment of the acute phase of the malady.

Arthritis has been the most common complication among the clinical cases studied and it obtains greatest prominence in the literature on the subject. Dorendorf makes the observation that as in Scarlatinal Rheumatism the incidence of arthritis varies in different epidemics of dysentery. It is more akin to gonorrhoeal rheumatism than to ordinary acute rheumatism. The larger joints are usually affected and fluid may or may not be present. In one case Nolf found that the synovial fluid, itself sterile, agglutinated the Bacillus Dysenteriae, but neither antidysenteric serum nor the salicylates have any specific effect on the course of the condition, which is probably due to toxic absorption from the abraded and ulcerated mucosa of the colon which has become the seat of a secondary infection. It would appear to be more common in Shiga infections and it has been encountered

during the acute stage of the disease and also after convalescence has been established. In no case did it give rise to endocarditis. This complication runs a course of seven to ten days and demands rest in bed with the application of local heat and later of massage as palliative and restorative treatment.

Conjunctivitis, mentioned by several authors, has not been a noticeable feature of the cases seen and where present, it was merely a transient hyperaemia of the conjunctivae which readily responded to simple local applications. Cardiac complications, toxic in origin and accompanied by oedema of the feet and legs with a small running pulse and poor cardiac sounds are not uncommon among the more severe cases and are explained by the finding at autopsy of a degree of cloudy swelling and anaemia of the heart's muscle, while in both Shiga and Flexner infections haemorrhages into the visceral pericardium and the muscle of the left ventricle have been observed. In some cases too, sudden death, comparable to that seen from cardiac failure in diptheria, has been met with in dysentery and may occur during the acute stage of the disease or early in convalescence. In addition to the degenerate cardiac

muscle, there is found in these, as in most fatal cases of dysentery, degeneration of the suprarenal glands.

Secondary anaemia follows an acute attack, but is, in most cases, amenable to general treatment, and disappears with the return of the patient to a normal dietary and exercise out of doors. But in cases that have run a protracted course, there is severe anaemia and asthenia, which frequently leads to death despite all efforts to sustain a failing nutrition. Experience of the pathological changes found after death explains this lack of response to dieting. Usually the case has come under treatment late in the disease, after an illness of five to ten days, when response to serum is disappointing; after an illness of three weeks or longer the patient dies of asthenia and at autopsy the stomach is found acutely inflamed with great excess of mucus secretion; there is patchy and intense congestion throughout the greater part of the jejunum and to a less extent in the ileum except in its lower nine inches, where there is as a rule, acute congestion. Similar conditions are met with in cases dying in the acute stage of the disease and would explain the finding by German observers of a condition of anacidity in

cases that have recovered from acute dysentery.

Herpes labialis is frequently present during the acute phase of the disease and lobar or broncho-pneumonia may develop during the acute stage or in the asthenic and debilitated subjects who have passed from the acute to the chronic stage of the disease. Haemorrhage from the colon has only been seen once, in an acute fatal case fulminating in type. Intussuception has been frequently seen at autopsy, but it has always apparently occurred just prior to or shortly after death. In children, however, observers report this complication as of frequent occurrence. Prolapsus ani is in much the same category and several other complications which have been recorded in literature may be mentioned, viz. motor and sensory paralyses, pyelitis, thrombophlebitis, nephritis. Oedema of the brain has already been mentioned as occurring in cases dying in a state of convulsion or coma and in some of these a condition of tetany has been observed.

Perforation has been found postmortem in one case and Woodward found eleven recorded among one hundred and eight autopsies. The case referred to was not suspected of perforation before death as tenderness over the colon was so very marked that special tenderness over the sigmoid did not attract any attention, as pain and

tenderness are usually most sévere in that region. At autopsy, however, the omentum was found closely and firmly adherent to the free border of the anterior curve of the sigmoid flexure: there was no peritonitis beyond the limits of this adhesion which covered an area of the size of a shilling: thinning of the sigmoid wall by ulceration had proceeded sufficiently slowly to produce an exudation on the peritoneal surface which attracted and glued the omentum over the base of the ulcer before perforation actually became complete. In one other case similar perforation was presumed to have occurred and healed during the acute stage of the disease and in convalescence this patient had a well defined indurated area palpable over the free border of the colon at the sigmoid flexure.

Manson reports an interesting case with large rectal polypi as the result of proliferation of the mucous membrane and Jacob has described the occurrence of febrile attacks during convalescence and after all signs of the disease have disappeared, similar to those reported among convalescents returned to England from Gallipoli. In a few cases where response to treatment has not been satisfactory or in which the process has been

so acute that the patient is left with a fibrosed condition of the colon in its whole length, there results a very irritative colitis which periodically manifests itself in a sudden call to stool once, twice or even five times a day, the call being so commanding as to amount almost to incontinence. The slightest dietetic indiscretion is sufficient to excite this condition.

Diagnosis.

Once the disease is established in epidemic form and amoebic dysentery is not endemic, there is really little need for bacteriological investigation except of the mild cases and the concomitant diarrhoeas. This view is supported by Kraus, who regards bacteriological examination as necessary only from the epidemiological point of view and in the early cases, and by Friedmann, who states that all cases of epidemic haemorrhagic colitis are dysenteric. For the clinical diagnosis of the cases the most important information is obtained from regular and systematic examination of the stools, for even in the mildest cases if this examination is thorough and more especially if it is supported by microscopic examination, mucopus or mucopus and blood will be found in some of the earlier

specimens. In mild and in recurrent cases which have lasted for one to three days only, I have frequently demonstrated the presence of mucopus in one or more of the three to five stools passed in the twenty-four hours. And it is surprising how often mucopus will be found microscopically in very innocent looking specimens. In most of the acute cases there is little need for microscopic examination of the dejecta which look like unaërated sputum from a catarrhal bronchitis with or without the presence of blood which may be dotted, streaked through the mucopus or closely incorporated with it in an exudate resembling red currant jelly. Microscopical examination should, however, be made of all specimens to corroborate the presence of pus cells and not mucus alone and to exclude the presence of pathogenic protozoa and their cysts or the ova of intestinal worms. From amoebic dysentery the bacillary type is differentiated by its more acute onset, more severe initial diarrhoea, more marked and more widespread tenderness over the colon, the freedom from hepatic involvement, the quick response to early treatment by antidysenteric serum, the shorter course of the disease even where serum is not employed,

and by the quick response of amoebic cases to treatment with emetin. Typical acute onset, with or without vomiting and rise of temperature, slow pulse, furred tongue, typical facies, typical stools and tenderness over the colon or more especially over the sigmoid flexure, griping, tenesmus and a leucocytosis should at once suggest dysentery and under such conditions, where the disease is epidemic, in no severe case should specific treatment be withheld pending a bacteriological examination. Findlay has reported on the differential diagnosis of bacillary and amoebic dysenteries by the reaction of the leucocytes to a one per cent solution of iodine in potassium iodide, the iodophile reaction being present in the former and not in the latter, apart from secondary infections; and by the presence in an increased percentage of the leucocytes from the latter infection of nuclear pseudopodia. But the reservations necessary and the presupposition of a microscope and the time and ability to use it, lead one to suggest that more profitable and reliable information can be gained by microscopic examination of the faeces for the presence of amoebae or their cysts. Becher even goes so far as to distinguish clinically between Shiga and Flexner infections indicating that the former is less explosive in onset,

with a milder but longer sustained pyrexia, a more protracted course, more marked anaemia and general toxaemia and a higher leucocytosis. Such a refinement is rarely necessary for the clinician who uses a polyvalent curative serum and observation on clinical cases has not corroborated this finding, as in many of them the characteristics attributed to Shiga infections were all claimed by genuine Flexner infections and in several cases both organisms have been recovered from the same patient at one time. Much has been written on the finding of entamoeba histolytica and its cysts in dysenteries contracted in France, but though the French have had epidemics of amoebic dysentery in the South and though cysts indistinguishable from those of entamoeba histolytica have been found in association with Shiga and Flexner infections, in no case, apart from those who had been exposed to infection in the East, have active entamoebae been found in cases investigated in the Somme area in 1918-1919. The reports of protozoologists of the presence of entamoeba histolytica or its cysts in persons who have never been out of England lead one to suggest that the

true entamoeba of the Tropics either does not flourish in the active stage in temperate zones or is closely simulated by a non-pathogenic species of these climates.

From cholera dysentery is distinguished by the character of the stools and the rapidly progressive character of the former infection, but mild cases of the former and a choleraic type of the latter have to be considered and here it is that bacteriological diagnosis is essential. From enteric fever dysentery is differentiated by the acute onset, acute mucopurulent diarrhoea, the tenderness more marked in the left iliac fossa, the leucocytosis and the shorter course of the disease; but here again typhoid types of dysentery with marked toxaemia are met with at some time during an epidemic and bacteriological diagnosis has to be called for. The history in cases of food poisoning helps to differentiate these from dysenteries but again the matter should be finally settled in the Laboratory as vomiting and even a certain degree of collapse may be found in cases of dysentery as well as in food poisoning. Diarrhoea may be produced by intestinal worms but though blood is present in cases due to bilharzia

the typical mucopurulent or sanguinolent stools of dysentery are not found in these cases and microscopical examination of the specimen usually reveals the presence of the ova of the respective worms. A dysenteric like diarrhoea, too, may be found in the terminal stages of chronic wasting diseases such as tuberculosis and a colitis due to new growth has to be borne in mind and carefully excluded especially in middle-aged subjects, while in neurasthenics mucous colitis simple in origin is met with.

Prognosis.

In the cases dealt with clinically the prognosis, immediate and remote, would in the great majority be given as favourable though a mortality of some 0.5% has to be recorded and Nolf and Colard have had a mortality of .25% in the epidemic among Belgian troops in 1917. But in some of the German epidemics a mortality of 20-25% has been recorded and in a small epidemic among German prisoners of War during the winter of 1918-19 the mortality rose to 6 or 8%. The earlier the case comes under general or specific treatment the better is the prognosis but a few fulminating cases will be experienced which do not respond

even to early treatment. The morbid anatomy and histology will be dealt with under Part II but generally speaking Shiga infections have been the more severe in most epidemics recorded and in fatal cases, apart from death in the fulminating type of the disease, it is remarkable how frequent are old pulmonary or renal lesions which have undoubtedly contributed materially to the fatal issue. Chiavi has reported the presence of old tuberculosis or acute pulmonary disease in 40% of 46 fatal cases. Klemperer gives a comparative analysis of mortality according to age groups from which it is shown that the disease falls most heavily on the very old and the very young and is least severe in young adults of 10 to 40 years.

Treatment.

Treatment of the disease may be discussed under the general, medicinal, and specific methods employed and a judicious combination of all three is the most successful.

General Measures. Rest in bed is essential and there the patient should remain until the acute stage has passed and the stools have returned to normal in appearance and in frequency. The bed pan should be

used from the outset in severe cases and in grave cases where incontinence occurs the dejecta should be voided on to pads of tow or cotton wool. The body should be sponged daily and in grave or chronic cases a very careful toilet of the back and legs must be maintained throughout, to prevent the occurrence of bed sores, and the mouth and teeth require regular cleaning. The colon must be afforded as much rest as possible compatible with the maintenance of nutrition, by means of a fluid but generous dietary consisting of milk, diluted or peptonised, beef tea, barley water, albumen water and whichever simple non-alcoholic drink the patient prefers for the allaying of thirst. This fluid diet can only be enhanced with caution as too early resumption of solids will only lead to relapse of the diarrhoea and a full diet has to be approached slowly through a probationary period on milk foods, eggs, white fish, boiled or steamed, chocolate, bread and butter, minced chicken, minced meat and vegetables. But in some acute cases the vomiting is so severe and so easily excited that the patient cannot tolerate even the blandest of fluid nourishment and sedatives have to be given to obtain relief and to make nourishment

by the mouth possible.

When dehydration of the tissues is marked normal saline should be regularly administered subcutaneously or intravenously and in some of the worst cases continuous salines have proved beneficial. Their effect is temporary only but they relieve the severe thirst from which these patients suffer, they increase the fluid content of the blood and help to steady the heart's action.

Lavage of the rectum and colon by means of warm (99-100° F.) normal saline is most beneficial (Loeb uses 200 cc. water at 98.4° F.) and the addition of 10-20 minims of $\frac{1}{1000}$ adrenalin solution and 5-10 minims of a 1% solution of cocaine will increase the astringent and sedative effect. Where tenesmus is severe a morphia suppository may have to be used prior to the lavage in which case the cocaine solution is omitted. A stomach tube is inserted very gently through the anus and introduced as high up the colon as possible - the patient lying on the right side with the knees drawn up, and the irrigating solution is introduced slowly and by gravitation. This treatment quickly reduces the number of stools, relieves the griping, and the tenesmus and is a most useful adjuvant to

specific serum treatment. I understand that in East Africa the colon was washed out in some severe cases through the appendix but that results were not sufficiently encouraging to warrant an appendicostomy in all such cases.

Medicinal. No drug is known to have specific action on the dysentery bacilli. Intestinal antiseptics such as salol or bismuth salicylate are useful as sedatives rather than disinfectants, and calomel, castor oil, and the sulphates of magnesium and sodium are each of them favoured by different observers. In mild cases calomel in half grain doses hourly for eight hours on each of two alternate days is often sufficient to stop the diarrhoea and the further treatment of these cases is dietetic with morning salines to prevent the constipation which usually follows. Castor oil and calomel are used by others but salines are in greatest favour rivalling the antidysenteric serum as a routine treatment. Half drachm doses of Epsoms Salts are given every hour until the stools become faeculent and continued thereafter two hourly, four hourly or twice daily as required. But salines cannot be

looked upon as in any way specific and except in mild cases should be combined with serum treatment. Opium and its derivatives and the other sedative preparations are from time to time necessary to allay vomiting, griping or tenesmus, to correct sleeplessness and to counteract muscular and articular pains, while turpentine in fine minim doses by the mouth has been found useful in the treatment of hiccough. Astringents should as far as possible be withheld and the colon kept as free from exudate as possible. Fayolle uses charcoal by the mouth - half to one ounce daily - in all cases of dysentery; and in chronic cases the French greatly favour tincture of iodine which is given by the mouth, while Geissler used it with success as a rectal injection in chronic cases - seven and a half minims of ten per cent tincture of iodine in a pint of camomile tea daily until the stools become normal. Stimulants should be reserved for cases of collapse when the pulse is small and of low tension and in these cases strychnine and adrenalin have been found very useful.

Serum Treatment. Shiga in 1898 first demonstrated the value of immune animal serum in the treatment of dysentery and since that time it has been extensively

used. German writers during the war have not as a rule been enthusiastic over the results obtained from its use, a circumstance which may find some explanation in the fact cited by Professor Umber that there are on the German market thirteen different sera by six different firms! This has not been the experience acquired in the treatment by serum of cases in France, and French and British workers alike attribute excellent results to its use. The polyvalent antidysenteric serum prepared at the Lister Institute has been used in my cases and the French use the serum prepared at the Pasteur Institute. The essentials to success in this line of treatment are two - early treatment, preferably before the fifth day of illness, and the exhibition of the remedy in large doses. When secondary infection has taken place, immune serum can have no specific action; and small doses have little or no effect. In ordinary cases it should be given subcutaneously or intramuscularly and in very severe cases intravenously. Dufourt and Devic using the Pasteur serum recommend the following dosage:-

(1) Very severe haemorrhagic cases -100,120,or 160 cc. in one day & less on following days.
(2) Grave cases with 50 stools p.day-80,60,40,20 & 20 cc. respectively on each of 5 da
(3) Severe cases with 40 " " "-60,40,20 & 20 respectively on each of four days.
(4) Benign cases . . . . . .40 & 20 cc. respectively on each of two days.

Serum sickness of varying severity and manifesting itself in many ways has to be anticipated in some cases and where patients have already had horse serum previously in the prophylactic or curative treatment of other diseases desensitizing of the individual has been performed by the giving of half, one, or two cubic centimetres of the serum at hourly intervals, the pulse and temperature being carefully charted the while. This method has been found satisfactory in guarding against the more severe anaphylactic phenomena but neither the serum sickness nor the anaphylactic manifestations observed have had any relation to the dose of horse serum administered. An interesting and instructive analysis of the effect of serum as contrasted with salines in the treatment of bacillary dysentery in Malta has been recorded by Dr.Dobrashian and as the cases seen there were presumably more severe than those usually met with in France the figures are the more conclusive.

Shiga cases - 176 treated with serum only.
172 with salines only.

Day of disease on which treatment is begun.	Cases treated.	Relapse.	Carriers.	Arthritis.	Cardiac complications.
(1-5) days.	(64 serums	3%	1.5%	-	6%
	(93 salines.	15%	10.7%	5.3%	14%
(6-10) days	(73 serum	4%	2.7%	-	16.4%
	(56 salines.	19.6%	7%	5.3%	16%
(10 or more) days	(39 serum	5%	10%	5%	15.4%
	(23 salines.	21.7%	21%	4.3%	9%
Flexner-Y cases	(35 serum	3%	3%	-	17%
(1-10 days).	(67 salines.	14%	6%	-	15%

From the above table it will be seen how important it is to have serum treatment begun early in the disease and that in all the earlier stages of the disease serum treatment offers better results than salines alone. A monovalent Shiga serum is available but until diagnosis is confirmed bacteriologically the polyvalent serum should be used. Polyvalent curative vaccines have been advocated in treatment by the Germans but as they are recommended for mild cases which so frequently recover without specific treatment and as they are further combined with serum the case for their use cannot be taken as established.

Prevention and Prophylaxis.

Efficient sanitary arrangements, good health, good food and water, and good housing, are the principal safeguards against the invasion of a district by bacillary dysentery and where the disease is endemic strict attention to the same conditions and to personal hygiene on the part of the individual will protect him against infection.

Much work has been done during the war on elaborating an efficient prophylactic vaccine. The difficulties in the way have been the great toxicity of the Shiga bacillus, the slow response by the individual vaccinated in the production of immune substances and the short duration of immunity when it is once established. As the result of an elaborate series of experiments Boehncke and his collaborators have produced a vaccine - "dysbakta"-which has been extensively used in Germany in civil and military populations. It is prepared from Shiga and Flexner strains obtained from several localities and ultimately contains Shiga toxins balanced by antitoxins with an excess of toxins obtained from the presence of emulsions of dead Shiga and Flexner bacilli. This toxic-antitoxic or sero-vaccine is

given in doses of .5, 1. and 1.5 c.c. at five day intervals or in 1 and 2 c.c. doses at seven days' interval. The local reaction is moderately severe and the general reaction resembles that obtained from the use of antityphoid vaccine and where severe reactions have taken place they have been attributed to faulty technique - too deep an injection or puncture of a vein. The protection afforded lasts for three to six months and among vaccinated and unvaccinated the mortality has been recorded as 0 and 1.9 and the incidence as 1 and 3.3 respectively. Steuernagel reports upon its use in an area where the disease was not endemic and where during the epidemic season the subsequent morbidity did not rise above 3 to 5% while in a neighbouring unprotected community the morbidity stood at 95%. He further records in an endemic area fifteen days after the institution of vaccine prophylaxis a fall in morbidity of 5% and in mortality of 65%. Schelenz, Steiner, Sachs-Muke and Burgess report similarly good results from its use. A somewhat similar sero-vaccine has been prepared and issued by the Royal Army Medical College and Gibson has recorded favourable results

obtained from an experimental series of cases. These vaccines are given to best advantage to units or individuals exposed to infection and as the protection is short-lived they give best results when given annually in the months of May or June.

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PART II.

BACTERIOLOGICAL.

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PART II. BACTERIOLOGICAL.

Short History.

As already described in Part I. entamoeba histolytica discovered by Losch in 1875, and more fully described by Kartulis and Shaudinn, was the first causal agent associated with dysentery in the human subject and it was not till 1898 that Shiga discovered the bacillus named after him, in the epidemics of dysentery prevailing in Japan while Kruse in 1900 found the same organism in dysenteries in Westphalia. This bacillus had as its fermentative characteristic, the production of acid without gas in glucose media. Flexner, in 1900, described the first member of the group now named after him, which has, as its primary characteristic, the production of acid without gas in glucose and mannite media, this original member also producing acid in maltose as a secondary characteristic; while in the same year Strong isolated another member with the primary characteristics of the group and a secondary characteristic in/

in the production of acid without gas in saccharose; and in 1903 Hiss and Russell described another strain which had the primary group characteristics alone and which has been known as the "Y" bacillus. Since that time many strains have been added to this group of mannite-fermenting dysentery bacilli, and attempts at their classification on fermentative and serological reactions, have frequently been made. The work of many competent observers has served to indicate that these organisms, while stable in their primary fermentations, cannot be classified on secondary characteristics which are notoriously inconstant in different strains and in the same strains after sub-cultivation. In the following treatise, which is the record of part of the work undertaken during a dysentery epidemic in France, no attempt is made to found a new system of classification, but rather to show how futile and unnecessary it is in routine work, while evidence will be adduced to dispute the admission of certain variants to the mannite fermenting group and to preserve the integrity

of the Shiga bacillus as one which is always true to type and admits of no variants.

Media used.

Nutrient agar.

MacConkey's neutral red bile salt lactose agar.

Peptone water (1-3% Fairchild's or Chapoteau's) Reaction + 10 Eyre.

Gelatin.

Litmus milk.

Carbohydrate media (1% of all carbohydrates except dulcite (.5%) in peptone water with litmus as indicator.)

Sugar-free peptone water with litmus as indicator. Reaction + 4 Eyre.

Russell's double sugar medium. 1% lactose and .1% glucose in an agar base with litmus as indicator.

Methods employed.

Examination of Faeces:- A specimen obtained as fresh as possible is examined macroscopically for mucous or muco-pus and a suitable portion of such, if present, (even on solid stools there is frequently a deposit of muco-pus on the surface of a scybalous mass), is picked off on a stout wire, thoroughly washed and broken up in warm sterile saline and a small portion of this suspension spread

on a MacConkey's plate by means of a platinum loop and the plate incubated at 37° C. for 18 - 24 hours. The glass rod spreader has not been used as it was frequently found to produce a rather crowded growth from which it is difficult to pick out non-lactose-fermenters and which frequently necessitates the replating of likely colonies; and after a short trial the brilliant-green enrichment method was given up as more satisfactory results were obtained from the direct method, an experience confirmed by Fletcher, who, in the course of examination of one thousand convalescents 'never obtained a positive result from the brilliant green method, while by the direct method in the same series of cases, he recovered bacilli of the mannite fermenting group eighteen times and Shiga's bacillus once'. A portion of the suspension is also examined microscopically for the presence of pus, epithelial cells, amoebae or their cysts, or the ova of intestinal worms; and where anything suspicious of amoebic infection is found, a freshly passed specimen is immediately called for and examined.

After incubation for 18 - 24 hours at 37° C.

the plates are read and likely colonies are sown into broth which, after incubation from three to four hours at 37° C. is examined in hanging drop for motility. The carbohydrate media are also inoculated, viz. glucose, lactose, saccharose, mannite, dulcite, and maltose; and an agar slope is inoculated preparatory for macroscopic agglutination. The sugars are read the following morning and if the fermentative reactions suggest any of the pathogenic organisms an emulsion in normal saline is made from the agar slope and agglutination by the respective specific antisera indicated is sought for. If the organism prove to belong to any of the pathogenic groups, it is sown into litmus milk and into gelatin by stabculture. It is thereafter maintained in the carbohydrate media for 17 - 21 days and in litmus milk and gelatin for 28 days or longer. Russell's double sugar medium was employed for a short time but as the production of gas in the butt was frequently slow in appearing, its use as a routine method was discontinued. Indol was tested for after 24 and again after 72 hours' growth in broth in which the organism was maintained for this period and a portion

of the fluid was examined on each occasion by one or more of the three following methods, Erlich's para-dimethylamino-benzaldehyde re-agent being used in each case.

(a) Extraction with ether:- A portion of the broth culture is shaken up with ether and allowed to stand for a few minutes, the ether is then pipetted off and settled on the top of a few drops of water in a small agglutination tube: a small quantity of Erlich's re-agent is then added to the tube by means of a pipette, when the rose pink colour of a positive reaction quickly appears as a ring between ether and re-agent without the necessity of adding potassium persulphate. This method, recommended by Glynn, has been found very convenient when a number of strains were being examined at one time.

(a_1) Extraction with ether and the addition of Erlich's re-agent direct to the broth followed by a few drops of saturated potassium persulphate, has been found quite satisfactory in routine work and no difficulty has been experienced in differentiating between the true rose pink of a positive reaction and the brownish colouration sometimes produced by the action of the re-agent on the constituents of

the culture media. The reading is more easy and definite if the tube is allowed to stand for a few minutes. The first method (a) is very useful when, in times of stress, the indol reaction is sought for from the mannite tube and in that case it is the only method applicable owing to the presence of colouring matter in the sugar tubes.

(b) Amyl alcohol method:- Add Erlich's re-agent direct to the broth tube, followed by a few drops of potassium persulphate and then add amyl alcohol, shake well and allow to settle, when the alcohol will extract the rose-pink coloured compound. This method has also proved quite satisfactory in routine work.

Glynn has shown that for the successful production of indol a peptone containing free tryptophane is necessary and advises the use of Defresne's peptone. The peptones employed in our work were thought to be slow in yielding indol from the mannite fermenters and for that reason the percentage of peptone was raised from one to three per cent in the media. But the real indol producers were always actively positive in 18 - 24 hours even in the weaker preparations, so it would appear that a large number of strains of mannite fermenters has been encountered, which are not indol

producers even in the stronger preparations of peptone.

Agglutination. An 18 - 24 hour growth of an organism on an agar slope is rubbed up and emulsified in sufficient .85% saline to give a uniformly opalescent emulsion, which is then centrifugalised and mixed in small tubes in equal volume with varying dilutions of specific antisera also made up in .85% saline. The dilutions of sera are obtained by Max Neisser's technique, the lowest resulting dilution of serum used being as a rule $\frac{1}{25}$ to $\frac{1}{15}$ of the titre of the pure serum for the homologous organism and a pipette of uniform bore being used throughout. Ten drops each of emulsion and serum are ultimately present in each tube;-e.g. 20 drops of $\frac{1}{100}$ dilution of serum are placed in the first tube in the series, 10 drops of saline in each of the others; 10 drops are transferred from No.1. tube to No.2. and these thoroughly mixed with the 10 drops of saline already present; 10 drops from No.2. are then transferred to No.3. and so on; 10 drops from the last tube being discarded. Then to each tube in the series 10 drops of the emulsion are added and the contents of each tube thoroughly mixed by means of the pipette, working from the weaker

up to the stronger dilutions. There are thus resulting dilutions of serum of 1/200, 1/400, etc. in presence of the living organism. The tubes, placed in a tin rack, are then immersed in the water bath to three-fourths of their height and are there maintained for four hours at 55° C. Half an hour after removal from the bath they are read and are re-read after standing for 9 - 12 hours at laboratory temperature. Complete agglutination is recorded when in any one tube there is complete macroscopic sendimentation after standing and perfect macroscopic clearing of the supernatant fluid, and for this reading a triple plus (+++) has been used in the records; when there is heavy sedimentation with opalescence or granular agglutination visible to the unaided eye in the supernatant fluid, a double plus (++) has been recorded; and where there is merely slight granular sedimentation and opalescence with or without visible granularity of the supernatant fluid a single plus (+) has been given.

The same technique has been employed in seeking for agglutination of his own or other strains by the patient's serum; live emulsions were prepared and treated in the way already described and the same

standards set for reading after treatment in the water bath. The final dilutions of serum in presence of the organisms were 1/20, 1/40, 1/80 1/160 and 1/320. Where Dreyer's Emulsions have been used the Dreyer technique has been used, the final dilutions being 1/25, 1/50, 1/125, and 1/250: these were treated in exactly the same way as the others and the results read after the same lapse of time; but standard agglutination was recorded where flocculation in a tube held against a dark background is visible to the unaided eye and the results are recorded in agglutinin units which are obtained by dividing the final dilution in which standard agglutination occurs by a factor, given on the bottle, which renders the results comparable with those obtained from the use of similar emulsions issued at earlier or subsequent dates. As this standard agglutination was something less marked than complete agglutination as defined by the Neisser method, the positive results obtained from Dreyer's Emulsions are somewhat higher even than those obtained from the use of the patient's own strain; and this discrepancy is the more marked in the case of the Oxford "Y" emulsions which have usually had a divisor factor of 2.2, so that standard

agglutination with this emulsion at a dilution of 1/25 gives the ten or more units necessary to indicate a presumptive positive finding; whereas by Neisser's method with live emulsions a positive has been recorded only when a triple or double plus occurs at a dilution of 1/40 or more.

Examination of Rectal Swabs.

In 1917 Friedman reported that while he frequently failed to recover dysentery bacilli from undoubted cases of the disease even in the early stages, he found no difficulty in obtaining practically pure cultures from plating of mucus obtained direct from the rectum or sigmoid through a rectoscope. Ellis of the Canadian Medical Corps was probably largely responsible for the introduction of this method into France, where it has had a very extensive trial with uniformly good results. In default of a swab on a longer wire carrier, the ordinary throat swab has been used, the cotton wool being rendered more adherent by the addition of a small amount of gum and the whole outfit is sterilised in the autoclave. Instead of a rectoscope, four inches of smooth glass tubing of half inch bore is gently inserted through the sphincter, the swab is introduced through this

improvised speculum and the cotton wool thoroughly rubbed over the mucosa of the rectum as high up as possible; the swab is withdrawn, placed in its container which carries a label with particulars of the case from which it has been taken, and sent to the Laboratory for examination. After a series of comparative tests, it was found that the following method gave good results in dealing with swabs obtained as above:- Add a few drops of warm sterile .85% saline to the tube containing the swab so as to moisten the cotton wool, rub a sterile platinum loop thoroughly all over the surface of the swab and inoculate a MacConkey plate by means of the wire loop; or the plate may be inoculated direct by rubbing the moist swab over a portion and further spreading effected by means of the platinum loop or by a glass rod bent at an angle of 95° - 100°. Thereafter plates are dealt with in the same way as those inoculated from specimens of faeces. Special swabs with a longer wire carrier have been used and are of advantage in that they can be inserted higher up the rectum; but it has been found post mortem that where dysenteric ulceration of the colon is present, the brunt of the disease invariably falls on the curve of the sigmoid and the last six inches of the gut. Specula of various types have been used and in times of stress when the sterilising

of specula between cases meant a considerable loss of time, good results have been obtained in a big series of cases where no speculum was used, the swab being carefully inserted directly through the anus, more slowly and carefully withdrawn. The patient should lie on his right side, the knees should be drawn up, the buttocks well separated and the swab gently introduced by rotary movement to the right corresponding to the winding of the cotton wool on the swab and after contact with the mucosa as high up as possible gently withdrawn by rotary movement in the same direction.

The advantages of the rectal swab are:-

(1) It can be obtained at any fixed time to meet the requirements of the Hospital and the Laboratory. The need to await specimens which are frequently forthcoming at unsuitable hours is thus overcome.

(2) The delay in collection and transit of specimens which favours the growth of other organisms at the expense of the dysentery bacilli, is overcome.

(3) It is comparatively clean to handle, both in the wards and in the Laboratory and large numbers can be quickly dealt with. One worker with good laboratory equipment and attendants can deal with one to two

hundred daily.

(4) It gives as high a percentage of positive findings as the direct faeces method and it would appear that delay in transit does not so invariably result in negative results as occurs under similar conditions when faeces specimens are used. I have on one occasion recovered Shiga's bacillus from a swab taken nine hours previously and despatched by post while Flexner-Y bacilli have frequently been recovered after such an interval - a very uncommon experience where faeces specimens are dealt with. Typhoid and paratyphoid bacilli have also been recovered from swabs taken in this way.

Its disadvantages are few:-

(1) Provided elementary care is taken, there is no fear of injury to the rectal wall. I have known of no such accident occur among many thousands of cases which have been swabbed by an intelligent orderly.

(2) It is unsuitable for cytological examination. Where pus, amoebae &c. are sought for, specimens of faeces obtained in the usual way are necessary.

Abbreviated methods.

When in times of pressure even such a simple technique is impossible with a small staff and limited

equipment, the following methods have been found very useful and effective:- The plates are read as before and likely colonies picked off and thoroughly emulsified in sterile saline in small agglutination tubes suitably arranged in racks and numbered. Agglutination is then sought for by the hanging drop method on coverslips, the hollow slides supporting these being placed in the incubator at 37° C. for half an hour. Shiga serum, polyvalent Flexner-Y serum, and a mixture of equal proportions of each of the antisera to the enteric group are used, the final dilution in the drop in each case being one tenth of the titre of the pure serum for the homologous organism. The slides are read microscopically, 1/6th objective being used and only definite clumping is taken as positive, one of the sera present usually serving as a control. When agglutination is thus obtained, the emulsion from the corresponding tube is plated on MacConkey and a single colony sown into sugars after eighteen hours growth, four carbohydrates being employed viz:- glucose, lactose, mannite and dulcite, from one of which a hanging drop is put up after three to four hours incubation and mobility examined for. The following morning, if the fermentative reactions correspond to those of the pathogenic organisms agglutination by the

specific antisera indicated is next proceeded with. For this purpose the mannite tube is used and if acid or acid and gas are present, this is carefully neutralised at 100° C. by means of Sodium hydrate (N/10) which is added drop by drop. This neutralised growth in the sugar tube is then used for agglutination by macroscopic methods. This abbreviated ritual leads to a very big saving in sugar media, incubator space, and washing of tubes as only those strains which by preliminary agglutination give indication of relationship to the pathogenic groups are dealt with. The neutralisation by means of sodium hydrate must be very carefully attended to as excess of alkali has a prejudicial effect on the agglutination. And on no account can the carbohydrate media be dispensed with as one frequently finds slight and also definite microscopic agglutination of non-pathogenic micro-organisms even with serum at one tenth of its titre for the homologous organism. This is well illustrated by the results published by Smartt, who, taking microscopic agglutination phenomena as specific when using a presumably high titre serum at a dilution of only 1/300 found that, after reporting 58 positive results from examination of 263 specimens, only 7 strains of genuine dysentery bacilli could be

recovered from the emulsions which were originally made direct from the MacConkey plate. C.J.Martin (unpublished) in times of pressure uses one tube only containing .5% mannite in broth made from tryptic digest of casein (Cale) and Liebig Extract .25% - autoclaved at 115° C. for twenty minutes. Suspicious colonies are picked off the plates and sown into this tube, incubated for three to four hours at 37° C. and examined for motility and then left to grow for a total of 8 - 24 hours. Readings are based on following observations:-

Non motile	+	Acid	+	No smell.	=	? F Y.
do.	+	No acid	+	do.	=	? Shiga.
do.	+	Acid and gas	+	do.	=	discard.
Motile.	+	Acid.	+	do.	=	? Typhosus.
do.	+	Acid and gas.	+	do.	=	? Para A.B. or Gaertner.

Neutralise, if necessary, as above and agglutinate with the respective serum indicated. Ellis, Canadian Medical Corps, makes use of Russell's double sugar media in addition to the mannite tube, after a preliminary microscopic agglutination, and he then uses the slope of the double sugar growth to prepare an emulsion for macroscppic agglutination. The method employed under times of pressure largely depends upon the skill and experience of the worker, but microscopic agglutination direct from the MacConkey plate must always be confirmed

by fermentative reactions and later by macroscopic agglutination.

The Acid Agglutination Test.

Michaelis in 1915 emphasised the usefulness of this test in separating B.Coli, B.Typhosus and Paratyphoids A and B and he also recorded the observation that the Dysentery Bacilli even in the presence of a trace of serum gave negative readings. For the test take a rich twenty four hour growth of an organism on an agar slope, emulsify in about 20 C.C. of distilled water, centrifugalise to get rid of any clumps in the emulsion; add one drop of one in ten serum made up in distilled water, 3 c.c. of emulsion and 1 c.c. of each of the following six acid solutions to agglutination tubes in series, shake up the tubes, incubate at 37° C. for two hours and read results after the tubes have stood undisturbed for half an hour at Laboratory temperature. Michaelis measured out the acid solutions from standardised drop bottles but in our case acid and emulsion were added by means of graduated pipettes, the same proportions of emulsion and acid being maintained, viz. 3 to 1 or in practice .9 c.c. emulsion to .3 c.c. acid solution.

The following are the acid solutions:-

Number	1	2	3	4	5	6
Normal Na O H	.5.	5.	5.	5.	5.	5.cc.
Normal Acetic acid . .	7.5	10	15	25	45	85 cc.
Distilled water . . . q.s. ad 100 c.c.	87.5	&c.				

The reading is sometimes difficult as there is a certain amount of granularity obtained with several strains and as this is merely a stage in the process towards flocculent agglutination, it is evident that the test is not a sharply defined one, though many strains remain perfectly free from granular agglutination in presence of the acid. A series of comparative tests was carried out using non-acid-agglutinating dysentery bacilli and bacilli resembling the true dysenteries which were known to be acid-agglutinators.

(1) The absolute amount of serum was varied, the other ingredients being constant - one drop of each dilution being placed in each tube in the series.

Dilution of serum.	B.dispar. poss. agglutinator.							B.Dysenteriae Flexner.						
	1	2	3	4	5	6		1	2	3	4	5	6	
Nil	G	G	G	G	G	G	granular.	-	- sl.	- granular.	-	-	-	
1/40	-	-	-	G	+	++		-	-	-	-	-	-	
1/20	-	-	-	??+	++	+++		-	-	-	-	-	-	
1/10	-	-	-	+	++	+++		-	- sl.	- granular.	-	-	-	

(2) One drop of 1/10 serum in all tubes the amounts of emulsion and acid were varied, the proportions (3:1) remaining the same.

thus .2 cc. acid.) .3 cc. acid.) .5 cc. acid.
))
.6 cc. emulsion) .9 cc. emulsion) 1.5 cc. emulsion.

Similar readings were obtained in each series.

(3) Three different sera were used, one drop of a 1/10 dilution being added to each tube in its series - and a known acid-agglutinator used.

No.	1.	2	3	4	5	6	Tubes.
Horse serum	–	++	+++	+++	+++	+++	
Human serum	–	++	++	++	++	++	
Sheep serum	++	++	++	++	++	++	

(4) Younger growths were found less readily agglutinable than those given the full 24 hours incubation, while growths of three days were even more markedly positive. From these experiments it would follow that the total amounts of acid and emulsion are not significant so long as the proportions are maintained; the optimum dilution of serum is 1 in 10, one drop being added to each tube in the series; sera vary in their sensitizing properties the fresh sheep serum used being better than fresh human or horse serum (stock). The test is an empirical one and is of interest, but its value in

routine work as suggested by Michaelis and Andrewes is discussed in the later parts of this paper.

Results of Examination.

Analysis of the results of bacteriological examination are not encouraging, an experience recorded by several workers in the same field. During the early part of the epidemic, three specimens from each of 647 cases of dysentery or diarrhoea of three to ten days' illness were examined on successive days and yielded 146 positive results or 22.5% of all cases, not by any means a high figure. And when these cases are classified according to the microscopical appearance of the stools at the time of examination it is found that from among these 647 cases, 325 contained mucopus and blood and yielded 113 of the positive results or a percentage of 34.7 positives from specimens giving microscopical evidence of colitis at the time of examination, again a low figure. Explanation of these low positive returns was sought for as entamoeba histolytica was not present in these cases of apparently true dysentery and it was found that with a large number of specimens to be collected daily orderlies were in the habit of procuring these overnight or in the early hours of the morning and even

with the best possible arrangements, considerable time elapsed between the passing of the specimen and its plating on MacConkey, while the aid of a cool chamber or ice chest in which specimens were placed, though it improved results, still left much to be desired in the percentages obtained positive. With a small staff too, it is obvious that large numbers of specimens even when they reach the Laboratory cannot be handled with the expedition shewn to be necessary to the obtaining of good results by several workers in this field. Nor can the patient be expected to accomodate his evacuations to the needs of the Laboratory and nothing short of day and night team work could meet the case. When, therefore, the number of specimens became unmanageable and there was no doubt as to the nature of the epidemic prevailing, examination was made by rectal swab of all doubtful cases only, the so-called diarrhoeas, the clinically positive cases being evacuated to the Base. The figures for a consecutive number in this series are interesting as from a total of 1513 cases each of which was examined on three successive days, dysentery bacilli were recovered in 298 or 19.6% of the cases. This demonstrates the importance of these mild cases and it is interesting to note that the

physician in charge of them informs me that on reviewing the positives returned in this series, the clinical picture was usually in accord with a mild but genuine attack of the disease.

The cause of failure to isolate the bacilli from the stools in so many cases was partly due to the fact that they are quickly overgrown by other organisms present. This is well illustrated by Friedman who reports the isolation of dysentery bacilli in pure culture when mucus was obtained direct from the rectum and plated immediately, while no dysentery bacilli could be recovered from the faeces obtained from the same patient after it had stood at Laboratory temperature for an hour. Kolle and his colleagues have experienced the same difficulty while working on the Russo-German front, obtaining positive results six times only out of 1000 attempts in cases of undoubted bacillary dysentery. Seligmann reports equally unsatisfactory results from work at a Base Hospital but when he investigated cases nearer the front, results greatly improved and he gives an analysis of positive findings for one month having regard to the day of disease on which the case is first examined:-

Case examined in	1st week	- 70%	positive results.
do.	2nd do.	- 53%	do.
do.	3rd do.	- 18%	do.
do.	4th (& later) do.	- Nil	do.

C.J.Martin gives a similar analysis of 1053 attempts to redover the bacilli from cases presenting clinical features of the disease, summarised thus:-

Case examined in	(1 - 5) days	- 68%	positive results.
do.	(6 - 8) do.	- 17.4%	do.
do.	(11-15) do.	- 6.3%	do.
do.	(16-20) do.	- 3.1%	do.

While it is evident therefore that early examination of the case is necessary to the obtaining of a satisfactory percentage of positive results, little time should be allowed to elapse between the passing of the stools and its plating on MacConkey as is borne out by the following experiment (unpublished) by C.J.Martin:- A live emulsion of freshly isolated B. Dysenteriae Shiga containing 1000 million bacilli per cc. was added in equal volume to samples of fresh soft faeces and allowed to stand at Laboratory temperature for half an hour and after suitable dilution a portion of this mixture is plated out. It frequently happened that the B. Dysenteriae Shiga was

not recoverable, and even when successful the number of colonies present was only 1/100 to 1/10th of the number that should have appeared, depending on the numbers of B. Coli present on the plates. I have conducted experiments on somewhat similar lines, using B.Dysenteriae Flexner and growing it in broth in presence of non-pathogenic gas producing non-lactose-fermenters obtained from faeces, and also of strains of B. Coli obtained in the same way. It frequently happened that the presence of these other organisms in 1/50th or even 1/100th the numbers of the pathogenic bacillus lead to the extinction of the latter after one to four hours' growth at 37° C. and in many cases the addition of a few drops of a living growth of lactose fermenters in broth to a vigorously growing broth culture of dysentery bacilli led to a great diminution in the number of colonies of the latter recovered after plating at the end of two to four hours at 37°; while in several the dysentery bacilli failed to appear on the plates. D'Herelle has recently published an interesting experiment on the same lines. A small portion of faeces is emulsified in 20 cc. broth and filtered through a Chamberland L.2 filter; a trace of this filtrate killed a turbid culture of B. Dysenteriae

Shiga in a few hours and rendered the fluid clear in (12-24) hours. He does not consider this is the action of a ferment as it retained its potency after 935 passages and is regarded as a filtrable Bacteriophagum intestinale.

When therefore an epidemic is established bacteriological examination may profitably be confined to the examination of doubtful cases and this can be done best by means of the rectal swab if microscopical examination of the faeces does not afford evidence of a mucopurulent colitis which, as Friedmann suggests, is sufficient evidence of the disease in times of epidemic; and microscopical examination will also reveal the presence of intestinal parasites and their cysts or ova.

The Dysentery Bacilli.

The colonies on the MacConkey plate after 18-24 hours' growth at 37° C. are small and colourless. When examined by transmitted light they are translucent and the pink tint of the media gives them a certain semblance to late lactose fermenters. This characteristic is more noticeable when they are examined by obliquely reflected light under which they appear as delicate liquid looking colonies with a pinkish tint which is probably due to the fact that they do not bleach the

media in the same way as most non-pathogenic non-lactose fermenters do, and in addition, the latter are much more opaque and pearly white when examined by transmitted light. Further, in the case of colonies of true dysentery bacilli 'Shiga' colonies have frequently a tiny central body which is definitely pinker than the rest of the colony and tends on prolonged growth to form a central 'button' in the colony. In the case of Flexner-Y colonies this central 'button' is whitish. But late lactose fermenters, Morgan's No.1., B.Dispar, B.Ambiguus & B.Alkalescens, all resemble the genuine dysenteries on MacConkey though their tendency is to produce larger colonies, and when two suspicious colonies are found which have equal chances of expansion, the smaller of the two is the more likely to be true dysentery. But while experience is most helpful in singling out colonies for further investigation, many must be submitted to examination which ultimately prove to be negative. One point of supreme importance emerges from this experience and that is the frequency with which one finds minute colourless or pearly blue buds tucked away among or attached to lactose fermenters whose proximity seems to alter the distinctive tint already attributed to the colonies of

dysentery bacilli. These small colonies can never be neglected and frequently necessitate replating for purity. Dysentery bacilli are all non motile, non flagellate bacilli which produce a soft and fairly abundant growth on nutrient agar in 18-24 hours at 37°C. They grow readily in broth; in gelatin stab at 22°C. growth is slow, different strains producing different density of growth and little or no surface growth, while none of these bacilli produce liquefaction of this medium, even after prolonged growth. The dysentery bacilli stain readily with all the ordinary dyes and are gram negative; they are somewhat thicker and more plump than the typhoid bacilli and though not frequent, fairly long forms can be obtained by prolonged growth in broth. In litmus milk they all produce initial acidity followed in (3-10) days by alkalinity, which in most cases is again reversed, the milk returning after (15-17) days to its original neutral tint. In some cases of genuine dysentery bacilli, no alkalinity is obtained even after prolonged growth in milk, but in no case does clotting occur. In carbohydrate media growth is sufficiently active to show fermentative characteristics of some strains in (7-10) hours and after 18 hours' growth at 37°C. the Shiga bacilli produce acid without gas in glucose, while the other carbohydrates are not fermented. In the same periods the Flexner-Y's

produce acid without gas in glucose and in mannite and they have secondary fermentative characteristics which will be discussed in greater detail later. As some 10,000 specimens have been dealt with, only a limited number of the pathogenic strains isolated therefrom have been subjected to prolonged study in carbohydrate and other media.

Shiga group. Generally speaking their growth on ordinary media is slower and less luxuriant than that of the Flexner-Y bacilli, and they require more frequent subcultivation to maintain them alive on culture media. They are, however, much more toxic to animals and are usually regarded as producing the more serious forms of the disease in man; but they have not been found very frequently in the course of this work except among German prisoners and it is also interesting to note that among the 1513 cases of so-called diarrhoea already referred to 15 (=5%) of 298 positive findings were due to Shiga's bacillus and as will be shown later a large proportion of the fatal cases encountered yielded Flexner-Y bacilli; similar comment has been made by other workers. Nolf and his colleagues report Shiga infection in two out of fourteen severe cases and Friedrich reports an outbreak of Shiga dysentery in an

Austrian fortress, all the cases in which were mild - a circumstance he attributes to the good conditions prevailing in that garrison.

Initial acidity in litmus milk is followed in (3-10) days by a certain degree of alkalinity, which is not however constant in development or stable in character. Andrewes, growing these bacilli in an ovomucin media reports the production of alkali by all Shiga bacilli. This I have not been able to confirm in all cases, using a sugar free peptone at a reaction of +4 to phenolphthalein with litmus as indicator and having Paratyphoid bacilli, A and B, for comparison. I find that the development of alkali is variable in the time of its appearance, and the absolute amount produced at the end of 21 days' growth as estimated by titration with N/100 Na_2OH is also variable, some strains approaching near to Para B. in alkali production, others falling short of this by 30 or 50%, while in one of 22 strains tested, acid but no alkali was produced.

The secondary fermentative characteristics of the Shiga bacilli were studied by subjecting 22 strains to a prolonged sojourn in carbohydrate media. Twelve strains were found to produce acid in maltose in

(1-16) days (see Table I.). Nine of the original 22 strains were re-examined after subcultivation for (1-5) months and of these five were found to have acquired the property of attacking maltose while the remaining four had altered slightly in the time they required to effect this attack, some producing acid more quickly others more slowly than formerly. Saccharose fermentation has also been noticed in three of the 22 strains and when 9 were re-examined three strains were found to have acquired this property for the first time, while one of the original three had lost it. In four cases (Table I: 19-22) where each of two strains was obtained from the same patient at an interval of (1-3) days, slight variations are noticeable in their action on maltose and saccharose, one of the two strains requiring a longer period to produce acid than its fellow, while in one case maltose was acidified by one strain and not by the other. And in the case of some strains, a slight acidity in lactose in (7-10) days has been observed - an observation made by previous workers in this field.

B.Dysenteriae Shiga does not produce indol, a characteristic which is most useful in differentiating it from B. Ambiguus (Andrewes) or from the same organism which is known as the Schmitz bacillus in Germany.(Hirschbruck) See Table IV

Nine strains of Shiga bacilli were maintained in peptone water for 17 days and in no case was there any trace of indol production. This is in marked contrast with B. Ambiguus which produces indol readily in 24 or at most 48 hours, though two strains have been encountered which failed to produce indol but one of these was ruled out as it was motile. The other - No.9. in Table IV - was recovered from the same patient and the same plate as the true Shiga bacillus - No.2. in Table I. But though it failed to produce indol, it was easily differentiated from the true Shiga bacillus which was the pathogenic organism at work in this case. The former failed to agglutinate with Shiga antiserum at 1/40 of its titre, the latter agglutinated fully at end titre; the former was not agglutinated by the patient's serum at 1/20, the latter agglutinated fully at 1/80; the former agglutinated by Michaelis' acid test, the latter was not an acid-agglutinator. The acid agglutination test, however, cannot be said to have proved helpful in routine work on Shiga bacilli as claimed by Andrewes, for, though no true Shiga bacillus has been found to give a definitely positive reaction, 5 out of 19 strains of B. Ambiguus were found to be negative; 5 others, negative on first

isolation, only proved positive after subcultivation; while in 2 others a primary positive was reversed after subcultivation. All these strains of B.Ambiguus were indol positive and failed to agglutinate with antishiga serum in low dilution. The negative reaction cannot therefore be taken as admitting a Shiga-like organism to the group and a positive reaction should raise suspicion as to the title of an organism to such a place.

B.Ambiguus has been frequently encountered in the course of this work; its presence noted in acute, subacute and chronic cases; it has been obtained from faeces and from rectal swabs, often in pure culture, and frequently in association with true dysentery bacilli of Shiga and Flexner-Y groups. It resembles the Shiga bacillus in staining and in its growth and fermentations and in the secondary characteristics, viz. late fermentation of maltose and saccharose; but it is not agglutinated by specific Shiga antisera nor by the sera of patients from whom it has been recovered. The sera of 18 such cases were examined, in one only was any trace of agglutination obtained and that too at a dilution of 1/20 while by the same sera agglutination of their own or stock

Shiga and Flexner bacilli was obtained up to 1/320. C.J.Martin describes a stale fish smell from the broth culture of this organism and Andrewes has shewn that it is only pathogenic to animals in overwhelming doses and that it has poor antigenic properties but Thomson and Mackie found some strains toxic to animals in smaller doses. There is no evidence therefore that this bacillus can be regarded as causative of dysentery and it is even doubtful if it causes secondary infection of old dysenteric ulcers, as I have only once recovered it from such ulcers at post mortem and then too in very small numbers. It is permissable to suggest that most if not all the "inagglutinable Shigas" reported in the literature by Rist, Rajchman, Thomson and Mackie, and Hirschbruck, belong to this group and the conclusion arrived at is shared by Seligmann, Glynn and others, that true inagglutinable Shigas are very rare.

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Flexner-Y Group.

While Shiga bacilli are well defined and react to type, the same cannot be said of the Flexner-Y group. Flexner (1900) gave as the fermentative characteristic of the Flexner strain, the production of acid in glucose, mannite and maltose. Hiss and Russell's

(1900) 'Y' bacillus produced acid in glucose and mannite only. Strong's (1904) bacillus acidified glucose, mannite and saccharose. There were thus three historical primary strains which have since been added to by investigation in different fields, but it would appear that the variations are racial and local rather than specific and that the group is a large one whose members have the primary characteristic constant - viz. fermentation of glucose and mannite, with unstable secondary fermentative characteristics, involving a number of carbohydrates.

Taking the primary historical types as a basis of classification, it will be seen from Table 2. where 100 consecutive strains are tabulated, that fermentative characteristics would separate them into four groups, viz:-

(a) Nos. (1-9) belong to 'Y' group.

(b) " (10-17) " " Flexner group.

(c) " (18-57) " " Strong group.

(d) " (58-100) unclassed on historical basis as they produce acid in saccharose and maltose,

and the use of other carbohydrates would but increase the difficulty of grouping on fermentative reactions. Only a limited number and small quantities of these extra

carbohydrates could be produred; none of the strains examined were found to attack inulin, while one only was found to produce acid in salacin. C.J.Martin has examined a number of strains in presence of a large series of carbohydrates and finds different members of this group produce acid in dextrin, raffinose, arabinose, isodulcite, sorbite, and glycerine, the only carbohydrates which were not attacked being lactose, dulcite, inulin and adonite. In Table 3. will be found 11 strains, Nos. (101-111), which have been obtained from the same patient in duplicate or triplicate at intervals of (1-3) days in which the secondary characteristics are unstable, maltose or saccharose or both being fermented by one of the strains while its fellow fails to attack or is late in attacking the same carbohydrate. In the same Table (3) will also be found five strains (Nos.112-116) which have been examined in duplicate or quadruplicate, each substrain being propagated from a single colony picked off the one plate at the same time and treated in the same way, and even then the secondary characteristics are found to be variable as regards the fermentation of maltose and saccharose. And even further when the same strain is re-examined after subcultivation for (3-14) weeks it will be seen that these

secondary characteristics are again unstable and that in addition indol production is variable: one gains and two lose the power to split maltose, one gains and one loses the power to ferment saccharose and three acquire the power of producing indol in broth. C.J.Martin reports that two strains of Strong's bacillus, maintained at the Lister Institute, failed to attack saccharose when tested a few years ago. Fraser(1916) reports the same of a strain obtained from Manila. Martin reports also that the Flexner strains at the Lister Institute were found in 1915 to be inconstant in their action on maltose and saccharose and Hiss (1904) reported that his 'Y' bacillus after subcultivation produced acid in maltose, a faculty which I have had the opportunity of confirming by means of a direct descendant of the original 'Y' bacillus kindly supplied by Lt.Col. C.J.Martin.

It was early observed, too, that the acidity produced in maltose and saccharose media varied in different strains and in the same strain after prolonged growth in these media. These observations were confirmed by estimation of the acidity by means of titration with N/100 NaOH, one cubic centimetre

of the acid sugar media being neutralised at 100°C. with the alkali. While all strains produced a very closely approximating acidity in glucose and in mannite, the amount of acid estimated by titration in saccharose and in maltose varied within considerable limits depending upon the strain of organism and upon the time elapsing between the first appearance of acid and its estimation. Thus 1 cc. of glucose media required .031 cc. of N/1, NaOH, and 1 cc. of mannite media required .021 cc. of N/1 NaOH to neutralise; while in saccharose media the amount of N/1 NaOH varied from .006 to .011 cc. and in maltose from .011 to .024 cc. to effect neutralisation. It was further sought to cultivate this characteristic of acid production in the case of several strains which produced late acid in saccharose and in maltose but this was not always easily effected though some strains which produced late acid in these media were able after one or more passages through the media to effect its fermentation, in twenty four hours. C.J.Martin by a process of selection of saccharose fermenting colonies from solid media containing that carbohydrate was able to obtain its fermentation in fluid media in a few hours by one strain which he investigated, and it is interesting to note here that at that final stage this

strain had lost its agglutinability to 'Y' serum, a property which it quickly regained after growth on ordinary media. Several strains in this mannite fermenting group exhibit a tendency to bleach the media in saccharose and less frequently in maltose at the same time as or subsequent to the production of acid.

From a study of the Tables attached and the literature of the subject it is manifest that classification of this group on their fermentation reactions is unsound and that the only carbohydrate media of value in routine dysentery work are glucose, lactose, mannite and dulcite.

And when classification on agglutination by specific antisera is attempted, it is found that any classification based on fermentations is immediately upset, for while Hiss (1904) found that an antiserum prepared from his 'Y' bacillus agglutinated 'Y' strains and Flexner's equally well and that a Flexner serum agglutinated 'Y' in low dilution only, it will be seen at a glance from Table 3 that there is no relation between the agglutinability of strains by specific sera and their fermentative reactions, as Flexner sera agglutinate 'Y' bacilli Nos (1-9) and 'Strong' bacilli are equally well agglutinated by either Flexner or Y sera.

Generally speaking the strains dealt with would fall into five groups having regard to the two sera most frequently used, viz. R.A.M.C. Flexner and Lister Institute 'Y'.

(a)Those agglutinated near to end litre by Flexner serum only.
(b) " " " " " " " 'Y' " "
(c) " " " " " " "Flexner & 'Y' sera.
(d) " " moderately well by " " " "
(e) " practically inagglutinable by " " " "

But there is so much overlapping that such a classification is of little value and while absorption would carry one further even that does not arrive at finality and is impracticable where large numbers have to be dealt with. Of the inagglutinable strains four (see Table 3. Nos.116, 117, 118 and 119) had improved sufficiently in agglutinability after subcultivation to be embraced by the Lister Y serum, and the others (Nos.110(a) & (b); 111(a); 115 (a) and (b); 120 and 121), were later embraced by the polyvalent serum 'C.B.' prepared at the R.A.M. College. Nos.117 and 118 were obtained from Chinese coolies whose sera did not agglutinate their own strains beyond a dilution of 1/20. Nos.110 (a & b) and No.111 (a & b) were respectively obtained from two patients on the same day and the blood serum from No.111 who had been ill for nine days agglutinated

all these strains fully at 1/80 while serum from No.110 failed to agglutinate either of these. Owing to pressure of work it was not possible to examine the serum-agglutination of all the patients who produced these inagglutinable strains which had consequently to be held over for further investigation. One strain, which is not included in the above Tables and which conformed to the characteristics of the group in every way, producing late acid in maltose and saccharose and being indol positive, failed to agglutinate with any of the sera at my disposal including those for the enteric group and the Lister Institute polyvalent antidysenteric serum (therapeutic) or with the patient's serum on the 21st day of illness even at a dilution of 1/20. It was subcultured on agar and in broth and maintained in the cold, but no trace of agglutination was found though it was sought for seven times in the course of four months. It was a non-motile, gram-negative bacillus resembling the dysentery bacilli and giving similar reactions in litmus milk and gelatin.

Kruse (1907) would on grounds of agglutination divide the mannite fermenters into six groups and Hutt (1913) increases that number by absorption methods. Ruffer and Willmore (1909) using El Tor, Flexner, and Kruse 'D'

sera divide these organisms into two groups and Morgan (1911) found that several well known strains agglutinated well by Hiss and Russell's 'Y' serum and with one exception by Flexner serum in lower dilution; Sera prepared from Kruse A, D and E would embrace most of the German strains. More recent attempts at classification by means of agglutination and absorption methods have still left the matter unsettled and it has to be admitted that the group is a large one and embraces many local strains which have minor serological differences as they have secondary fermentative characteristics.

In litmus milk the mannite fermenters give readings equally as unsatisfactory as those of the Shiga type: an initial acidity is followed in (3-7) days by alkalinity which in turn frequently reverts to acidity so that after 21 days growth the milk returns to its initial tint. A number of strains were then grown in sugar-free peptone, Para-typhoid 'A' and 'B' being used as controls, and it was found by titration with N/100, Na OH that some strains produced alkali to the same extent as Paratyphoid B while others fell short of this standard by 50-70%.

Indol production by mannite fermenters.

As Glynn and others have found a large percentage of the strains isolated by them to give the indol reaction

it was thought that, in view of the small numbers of indol producers encountered in this work, some defect existed in the media used or in the methods employed. The peptone solution was therefore raised from 1 to 3%, but while true indol formers gave the reaction readily within twenty four hours even in the weaker peptone solutions, no increase in the numbers of mannite fermenters giving this reaction even after 10 days' growth was observed and the conclusion was arrived at that indol production is a variable characteristic dependent upon variations in the strains obtained in different localities.

Acid agglutination of mannite fermenters.

90 strains were examined but the findings of Michaelis and Andrewes cannot be borne out in their entirety as five typical strains which agglutinated to end titre by specific sera were acid agglutinators, usually in the last two tubes, and when these five were replated and tested some weeks later four of them still gave marked granularity in tubes 5 and 6 while the fifth still maintained a positive reaction though another strain from the same patient was consistently negative. Three poor serum agglutinators were, when first isolated, positive acid agglutinators

but this was reversed when they were retested some weeks later. Four strains which were inagglutinable by specific sera when first isolated gave at the same time definite agglutination with the acids, but when they were replated and re-tested some weeks later they had lost the property of agglutinating by the acid solutions. It is evident, therefore, that this test cannot be accepted as of real value in differentiating the true from the spurious among mannite fermenters.

B. Dispar and B.Alkaliscens (Andrewes) Table V.

Morphologically and culturally in their early fermentations these organisms closely resemble the mannite fermenters and are a source of considerable trouble in routine dysentery work; but they diverge from the true Flexner Y group in producing late acid in lactose (Dispar) and in dulcite (Alkalescens).

B.Dispar. Some 17 strains were studied in detail and were found to produce acid in lactose in (2-10)days and indol in peptone in three days though six of these strains were indol negative. Four strains were found to agglutinate with Lister Y serum to half titre and several others gave some agglutination with Flexner and Y sera at a dilution of 1/200, while two strains,

each of which produced acid in lactose in two days, in addition to agglutinating with Flexner and Y sera to half titre, were found to agglutinate with(R.A.M.C. and Lister) Shiga antisera beyond the titre obtained with the homologous organism. And further these two strains were agglutinated by the patient's serum at 1/40 and 1/160 respectively but sera from two normal persons were found to produce equally good agglutination of these organisms at the same dilutions. Two further strains were met with which gave some agglutination with the patient's serum at 1/40 but here again normal sera were found to have this property equally well developed. Andrewes has found members of this class of organism to have considerable toxicity for animals and to possess antigenic properties, but in view of the lack of confirmatory evidence from the serum of the patient, they cannot be accepted as causal agents of dysentery. They have all been found to be marked acid agglutinators and in this respect the test is helpful in a way, but it must be remembered that inagglutinable strains have been found to give similar though less striking agglutination by the acid solutions. In litmus milk any alkalinity produced by B.Dispar is masked by the fermentation of the lactose present in the media. In ovomucin Andrewes found that they produce alkali freely and this has been more or less

confirmed by growing them in sugar-free peptone in which they produce alkali more readily and usually to a greater extent than do the mannite fermenters.

B.Alkalescens.

10 of these organisms were studied: all produced acid in dulcite in (2-12) days: five were indol negative after three days' growth: all produced early and marked alkalinity in litmus milk: agglutination by specific antisera occurred rarely and that too was imcomplete and in low dilutions only. One strain No.11 in Table 5, which produced acid in dulcite and in maltose in eight days, agglutinated at 1/400 with 'Y' serum of titre 1/7000, while with the patient's serum complete agglutination was obtained at 1/20 and partial agglutination at 1/40and 1/80 and no agglutination by normal serum. This strain gave well marked acid agglutination. Andrewes has found that members of this class have very little toxicity for rabbits and very feeble antigenic powers. They are interesting anomalies encountered in routine dysentery work in which they, unlike B. Dispar, are not difficult to dispose of, as they rarely agglutinate sufficiently by antisera to entitle them to a place among the suspect mannite

fermenters, and when they are maintained in carbohydrate media their identity is readily established.

Mixed Infections.

While mixed infection has been reported in many instances among cases returned from the East in which dysentery bacilli of Shiga and Flexner-Y types have been associated with each other, with entamoeba histolytica, or with one or other of the enteric group, only three cases of mixed dysenteric infection have been encountered in this work, in each of which Shiga and Flexner-Y bacilli were recovered from the same patient at the same time. And though B. Typhosus was obtained once, B. Paratyphosus 'B' twice, and B. Aertrycke twice among dysentery suspects, these organisms were not in association with dysentery bacilli. Active entamoebae histolytica were only found in two cases who had presumably imported their disease from the East from which they had been transferred to the Western Front.

Other organisms.

While B. Ambiguus has been frequently encountered in pure culture from sanguinolent and mucopurulent stools it has usually been in association with true

dysentery bacilli of Shiga and Flexner-Y types, from which it is with difficulty distinguished on MacConkey plates after 18 hours' growth.

Organisms producing acid and gas in carbohydrate media have been of frequent occurrence, but a little experience helps to discard these from their appearance on MacConkey plates and they are tabulated below in their order of frequency:-

Acid & gas in glucose, mannite and Maltose motility + Indol +
do. {do. do. do. do. and dulcite} motility + Indol +
do. do. do. _____ motility + Indol +

The sera from cases of genuine dysentery were from time to time put up against members of all these types, but in no case was any trace of agglutination obtained at a dilution of 1 in 20, even when the patients own organism was employed. They cannot therefore be regarded as of any causal significance in the disease.

Streptococci have also been frequently found on the plates from cases of some duration and agglutination by the sera of the patients producing these has been sought for, but while agglutination was as a rule readily obtained up to a dilution of 1/200 it was found that the sera of normal individuals agglutinated these organisms in equal and frequently even in higher dilutions. Wilson (unpublished) has recently reported a series of cases

in which streptococci were abundant and in which agglutination by the patient's sera was obtained: in some of these cases he has isolated streptococci from the blood as well as from the faeces. One is frequently inclined to presume that these streptococci are a secondary infection in the dysenteric ulcers but no conclusive evidence in support of this view has been forthcoming from examination of the patient's sera.

Serological Diagnosis.

Much has been written and a great deal of work done in recent years to establish the value of serum diagnosis in the case of dysentery. Ritchie has conducted a large series of controls to determine the normal standards beyond which serum agglutination can be taken as diagnostic. He used the microscopic method so that his results, though very interesting, are not comparable with those detailed hereafter. He found that for B. Dysenteriae Shiga microscopic agglutination, read by 2/3" objective after two hours at 37° C. to indicate a positive diagnosis, should occur at a dilution of 1 in 50 or more; and for B. Dysenteriae Flexner-Y agglutination at dilutions over 1 in 128 may be taken as positive: with the exception of laboratory workers, students, and hospital staffs, whom he found to have a higher normal agglutinin content than

the figures given. The macroscopic method was used throughout this work and after a preliminary testing of 18 normal sera complete agglutination at 1 in 40 or over was taken as indicative of a positive result, the agglutination tubes having been kept at 55°C. for four hours as already described. In addition the agglutinations carried out each day were also controlled by at least one normal serum. C.J.Martin taking 40 normal sera as controls, places the percentage error in Flexner-Y agglutination returns at 2.5 and in Shiga cases at 2. He, using the macroscopic method, found that the percentage of positives among clinical dysenteries increased as the number of strains employed were increased, i.e. the larger the net the bigger the catch, a circumstance which he attributes to the possibility of one patient's serum agglutinating his own strain only or a closely allied one and no other: with one strain only a percentage of 40 positives would be obtained while when five strains were used the positive returns rose to 72.5%. These patients were examined between the 10th and 30th day of disease.

The work herein described was begun before Col. Martin's papers were studied and was undertaken with somewhat different ends in view, viz:-

(1) To determine the period of the disease at which agglutinins are first found in the patient's blood.

(2) To determine the earliest period of the disease at which serum diagnosis may be most helpful.

(3) To determine the percentage of genuine clinical dysenteries in which serum diagnosis may be expected to yield positive evidence of the disease.

For this purpose a total of 144 typical cases have been examined serologically at various stages of the disease and the results are tabulated in Table VI. on which the following generalisations are based:-

(1) There is evidence of the presence of agglutinins in the blood even on the fourth day of disease and their presence may be the more hopefully sought for on succeeding days.

(2) The figures for each day are small but generally speaking serum diagnosis may be most usefully appealed to between the 7th and 11th days of illness. In the later periods of the disease two possible factors have been at work, either (a) I have been unfortunate in the cases examined in that a number of them had developed no agglutinins or (b) that agglutinins had already been present and had disappeared.

(3) Even at the most favourable period of the disease (7-14)th. day and with his own organism, the patient's serum affords positive evidence of the disease on the accepted standard in 65% only of all cases. It would follow from these figures that, in 35% of genuine clinical cases of the disease, from whom dysentery bacilli have been recovered, serum diagnosis cannot be relied upon to afford definite corrobatory evidence of the nature of the disease. When one or more current strains are employed, the positives for the same period fall to 50%; with Dreyer's Emulsions 64% positives are obtained: while the positives obtained from the use of any or all of these strains amount to 75%, thus leaving 25% of the cases undiagnosed on serological grounds. This deficit is to be explained probably by the circumstance that agglutininsare not developed in all cases of the disease which is essentially a disease of the large intestine.

Shiga infections, of which there were but few, are included in these figures and in these serum diagnosis gives better results as agglutinins are presumably more readily developed; and it is worthy of note that in Shiga cases co-agglutination occurred even apart from a double infection. But in Flexner infections also co-agglutination was observed seven times, though the sera from these cases agglutinated the Shiga bacillus in lower dilution than they did the causal Flexner organism. In one case of double infection the patient's serum agglutinated the Flexner bacillus only, leaving the Shiga coinfectant untouched, but in the others the agglutinins for Shiga were much higher than those for Flexner.

And even in Flexner infections it is interesting to note that it frequently happened that a patient's serum would agglutinate his own strain and also similar strains obtained from other patients, while strains which differed from these were left untouched or agglutinated in low dilution only. In this connection strains are referred to as similar which agglutinated to the same extent with specific antisera: e.g. when on the same day two typical strains were isolated, one of which was agglutinated to titre by 'Y' serum only and the other to end titre by Flexner and 'Y' sera the

serum of the patient supplying the latter organism would show a decided preference for his own strain and vice versa.

The reaction on the part of the patient to polyvalent curative sera does not seem to be marked when judged by the agglutinins found in the blood one to five days after a subcutaneous injection of such serum and Cruickshank (unpublished) found little alteration in the patient's agglutinins one or two days after an intravenous injection of the curative serum. But the reaction was not studied over a prolonged period of treatment. Nor were the agglutinins to ordinary dysenteric infection estimated consecutively in a series of cases during the early and later stages of the disease and in convalescence: the percentages in Table VI. are based on different cases examined at different periods of the disease. Nevertheless one feels justified in concluding that apart from its interest to the serologist serum diagnosis cannot be claimed to afford results comparable to the amount of work entailed in carrying out the macroscopic method. It can not be usefully appealed to before the seventh day of the disease which by that time has frequently spent itself; a considerable number of strains must be employed to ensure a moderately high percentage of positive results; and even with the widest of nets, including the

patient's own strain 25% of cases still fail to yield evidence of infection, and among these are frequently included the mild ambulant types of the disease which are of such importance from the epidemiological point of view and which should be investigated early by clinical and bacteriological methods.

Morbid Anatomy.

Thirty-six cases of dysentery were examined post-mortem and, as in some of these death was not primarily due to that disease, favourable opportunities were afforded for the observation of the early pathological changes wrought by the dysentery bacilli in the tissues. Shiga's bacillus was recovered from seven of the cases and in four of these the disease was of the acute fulminating type, in two others it was chronic, and in the seventh oedema of the brain was the determining cause of the fatal issue. In thirteen cases mannite fermenting bacilli were recovered and the disease in these was less acute than in Shiga infections though a greater number of Flexner infections died of oedema of the brain. In the remaining sixteen cases, all of them genuine bacillary dysentery, the infecting organism was not recovered during life or after death as the patients were all admitted to Hospital late in the disease (14-21 days)

in a state of advanced emaciation and asthenia from which they died. Of the total of thirty-six cases, six were acute or fulminating in character, death occurring in three to six days: in eight there was marked oedema of the brain associated with as a rule an apparently mild dysenteric infection: and in seventeen of the thirty-six there was definite evidence of other disease chiefly bronchopneumonia, pulmonary tuberculosis, or old pleural adhesions also tuberculous in origin.

Except in the acute fulminating cases the subjects were usually much emaciated with great loss of subcutaneous, intermuscular and abdominal fat and in cases of several days' or week's duration, there was usually perianal dermatitis.

Brain. Apart from eight cases already referred to, there was little alteration found in the brain after death. In these eight cases however, there was extreme oedema of the white and the grey matter of the brain which visibly shrunk when cut open. There was in addition excess of fluid between the dura and the pia-arachnoid and the latter was ballooned out over the cerebrum on the vertical and posterior aspects of the brain by a clear serous fluid devoid of increase in cells and sterile on culture.

There was, however, no increase of fluid in the ventricles and it would appear that there occurred in these cases a serous exudate probably toxic in origin, and comparable with the glairy exudate to be described later in connection with the pericardium and the peritoneum. Warrington has suggested that the possibility of serous exudate into the ventricles of the brain in toxic systemic diseases should be entertained and it seems natural to conclude that a meningeal exudate of the nature described may also be expected from toxic diseases. Hart has described a series of cases of dysentery in which oedema of the brain was a marked feature, but unlike his cases those I have met with have all been in emaciated subjects. Towards the end of the illness coma, convulsions and tetany have been observed in these cases but it is remarkable how mild is the dysenteric condition found post mortem in cases which presented a typical clinical picture of the disease during life. There are frequently petechial haemorrhages on the pleura and pericardium, in these cases, the gastric mucosa is deeply injected and studded with stellate haemorrhages, there is patchy congestion of and haemorrhages into the mucosa of the jejunum and ileum and acute hyperaemia of the colon with or without superficial ulceration of the sigmoid and rectum, though in three cases ulceration in

these regions was well marked.

Thorax.

Apart from complications such as broncho-pneumonia and basal oedema there is nothing of note to report from examination of the lungs though petechial haemorrhages into the visceral pleura, usually on the diaphragmatic surface, have been noticed in several of the more acute cases and also in those in which oedema of the brain was present. Pleural effusion has not been observed and broncho-pneumonia has as a rule supervened in cases which have run a protracted course and sunk into a condition of asthenia.

There is rarely any excess of fluid in the pericardium but in several acute cases glairy oedema of the visceral pericardium over the posterior basal surface of the right ventricle and the right auricle and spreading over the large vessels at the base of the heart has been observed; in acute cases and those with oedema of the brain petechial haemorrhages into the visceral pericardium and less frequently into the muscular tissue of the left ventricle have been noted; in acute and in chronic cases there is degeneration of the cardiac muscle illustrated by the presence in varying degree of cloudy swelling and pallor of the muscle; but in no case has primary or

secondary endocarditis been found.

Abdomen.

The omentum is, except in very acute cases, of the thickness of tissue paper; free fluid has not been found in the abdominal cavity in any of these cases but in several acute cases there is a well marked glairy oedema of the mesocolon and in the posterior peritoneal tissues along the ascending colon and its hepatic flexure and to a less extent along the descending colon. In most cases the hyperaemia of the colon is noticeable from the peritoneal surface and the thickening of its walls is obvious also. The first chain of lymphatic glands draining the colon are acutely inflamed and stand out under the peritoneum as deeply congested nodules of the size of almond seeds, from which I have in one case been able to isolate the dysentery bacilli (Flexner). The glands draining the small intestine and the stomach are less acutely inflamed as a rule but the masenteric glands generally are all enlarged though in many cases they are not congested in the same way as those attached to the colon. In three cases there was moderate enlargement of the spleen, in three others this organ was greatly enlarged, soft, and friable with haemorrhages

into its substance and from one of the latter series a Flexner bacillus was recovered from the spleen after death; in all other cases the spleen was smaller than normal, rather firm and fibrous. The liver is usually enlarged and dark from venous congestion or pale from cloudy swelling, while in some chronic cases fatty degeneration is present. The pancreas is normal. The kidneys, apart from pre-existing disease, exhibit cloudy swelling and more rarely an early toxic nephritis; the bladder is frequently found distended. The suprarenals are usually apparently enlarged though in two cases they were found to be small and fibrous and in one case which had pulmonary tuberculosis small tubercles were present in these organs; in acute cases these glands are congested, especially the medullary tissue, and in more chronic cases the cut surface appears normal or there is cloudy swelling of cortex and medulla.

In all acute cases, in cases dying from oedema of the brain, and in most chronic cases, there is great excess of mucus secretion in the stomach, tremendous hyperaemia of the gastric mucosa with punctate and stellate haemorrhages superimposed. In some of these cases the whole of the inner surface of the stomach is of a bright pink colour and yet no vomiting of blood occurs

as a rule during life; in others the condition is confined to the fundus and the pyloric end. I have not been able to recover the dysentery bacillus from the stomach at autopsy. There is also hyperaemia of the duodenum and the upper part of the jejunum; from the latter site I have once recovered a Flexner bacillus. In the ileum patchy congestion increases in intensity as the lower end of the small gut is approached the last six to nine inches of which is almost always inflamed and its mucosa superficially abraded; from this portion of the ileum it is as a rule comparatively easy to recover the dysentery bacilli after death, in fact the chances of success from the lower ileum if it is affected are better than from a more chronic condition in the colon.

The degree and extent of involvement of the colon varies with the severity of the attack and the duration of illness. And while in most cases the colon is involved in the greater part of its length the brunt of the attack always falls on the rectum and the sigmoid flexure and when the disease is more widespread on the caput caecum, the splenic, and the hepatic flexures. In the earliest stages of the disease there is acute hyperaemia of the mucosa with enlargement of the solitary follicles which stand out like grey tubercles

upon the dark background. At a slightly later stage, tiny superficial ulcers the size of a pin's head are noticed in the inflamed mucosa and as the process advances these ulcers increase in size and involve the deeper layers of the mucosa and submucosa and their size varies from that of a split pea to that of a split almond seed, while in one case an ulcer one and a half inches in diameter was found close to the rectum. Ulcers are found as a rule over the whole circumference of the gut but the larger ones, oval in outline, are more frequently arranged with their long axis transverse to the attachment of the mesocolon. The edges of the ulcers are usually well defined and are undermined, and sinuses connect one ulcer with another, while in subacute and chronic cases each ulcer is an open abscess and when the colon is stretched over the back of the hand small beads of thick yellow pus exude from each of these. The base of the ulcer may be formed by mucous, submucous, muscular or serous tissue and a case of perforation has already been referred to in Part I. where the omentum had effectively sealed off a perforating dysenteric ulcer of the sigmoid flexure. And as the ulcerative process is arrested, healing processes begin, and there is seen over the edges, and extending towards the floor

of the ulcer, a thin white filmy growth of epithelial or connective tissue; but though several cases with healing ulcers have been seen, in no case was cicatricial contraction evident in these. When the lumen of the gut is first exposed, there is usually found adhering to the ulcerated surface, specks of faeculent and coagulated mucopurulent exudate light green, dark green or black in colour, depending upon the intensity of the destructive process. And when in old standing cases which have died of asthenia this exudate is removed, the partially healed ulcers look like smallpox scars on a deeply cyanosed skin. In most cases there is great thickening of the wall of the colon due to acute hyperaemia and cellular infiltration and in these the mucous membrane is heaped up in great abraded ridges between the deeper ulcers; but in a small number of cases which have run a chronic protracted course, there may be considerable thinning of the wall of the colon most noticeable in the caput caecum and the descending colon. In acute fulminating and diptheritic types of the disease there is intense congestion with most acute coagulation necrosis of the mucous membrane of the whole colon, though here too the sigmoid and rectum suffer most. The mucosa, greatly thickened, ridged and furrowed, is intimately involved in a coagulated infiltration, and

the whole coagulum is reddish grey, dark green, or black (gangrenous) in colour.

HISTOLOGY.

Mesenteric glands. There is well marked hyperaemia with round cell infiltration and in the more acute cases the connective tissue stroma is oedematous, the cells of which are large and rounded.

Spleen. Where the organ is enlarged there is hyperaemia, marked round cell infiltration, and extravasation of blood into the substance of the gland. Where it is normal in size or small, the spleen contains few round cells, there is granular degeneration of its cellular elements, the tufts are small and apparently diminished in number, and the fibrous stroma is relatively increased.

Liver. Cloudy swelling and granular degeneration of the liver cells are the only points of note in sections of this organ. In a few cases fatty degeneration has been noted.

Kidney. Cloudy swelling and in some cases an early tubular nephritis represent the changes found in these organs apart from cystic disease and old standing nephritis which were not associated with the dysenteric process.

Suprarenals. In all acute cases there is active hyperaemia of cortex and medulla with cloudy swelling, granular degeneration, and karyokinetic changes in the columnar cells of the cortex and to a less extent in the reticular layers of the medulla. In many of the less acute and in several chronic cases, the organs appear healthy.

Colon. Active hyperaemia of mucous, submucous amd subserous layers with extravasation of blood and infiltration of round cells into mucous and submucous layers and in some cases into muscular and subserous coats. Gram negative bacilli have been seen in large numbers lying on the muscular coat and it is interesting to recall that dysentery bacilli have been recovered post mortem by culture from the subserous and muscular coats, the platinum loop being introduced through the seared peritoneal lining.

When an ulcer is being approached the round cell infiltration into the epithelial layer intensifies until ultimately no epithelial tissue remains and a rupture in its continuity then results with intense infiltration into the underlying submucous layer and oedema and hyaline degeneration of the muscular coat beneath into which round cells frequently infiltrate. Where the healing process has begun fibrous tissue formation, and

where mucous tissue remains, proliferation of epithelial elements set in; but where much destruction has fallen upon the epithelial tissues there is most extensive fibrous tissue formation found in the mucous and submucous areas. Ulcers in the lower end of the ileum are more superficial and the infiltration is less intense but otherwise they do not differ from those in the colon.

In acute fulminating cases where coagulation necrosis has occurred, mucous and submucous layers are replaced by a coagulum of granular material in which cellular elements are practically indistinguishable and even the muscular layer is so oedematous and its nuclei stain so faintly or not at all, that it is with difficulty distinguished from the rest of the coagulated mass, and where muscle can still be distinguished it shows well marked cloudy swelling and hyaline degeneration.

SUMMARY & CONCLUSIONS:

1. Bacillary Dysentery can be recognised clinically especially if the case is seen early & the faeces are examined microscopically.

2. Specific treatment by curative sera in adequate dosage & general treatment on rational lines should be instituted early.

3. The important factor in the spread of the disease is the mild ambulant case, the so-called diarrhoea.

4. The disease usually spreads by direct or indirect contact but contaminated water supplies may cause an epidemic.

5. Prophylaxis by sero-vaccine is of temporary value.

6. Bacteriological investigation to give satisfactory results must be begun in the first few days of the disease & specimens of faeces must be examined immediately after they are passed.

7. Examination by rectal swab gives satisfactory results.

8. Serological examination leaves 25% of cases undiagnosed.

9. Once the disease is discovered in a locality attention should be focussed on cases of diarrhoea.

10. Shiga bacilli conform to type & inagglutinable Shigas are rare. B. Ambiguus is distinct from the Shiga group & has no causal relationship to the disease.

11. The mannite-fermenting bacilli form a large group the sub-division of which by ordinary methods is unsatisfactory. The secondary fermentative characteristics of this group are unstable. The title of a doubtful strain to inclusion in this group must be decided on the sum of evidence obtained from cultural,

biochemical & serological reactions. This may necessitate its subcultivation in carbohydrate & other media for several days.

12. B. Dispar & B. Alkalescens are differentiated from the true mannite-fermenters biochemically & their claim to inclusion in this group as causal organisms has not been sustained.

13. No causal relationship has been established between the streptococci & other organisms frequently isolated from these cases & the acute form of the disease.

14. The only carbohydrates of value in dysentery work are:- glucose, lactose, mannite, & dulcite.

15. A high-titre polyvalent antiserum should be used in the search for dysentery bacilli of the mannite-fermenting group, but direct microscopical agglutination must not be taken as specific.

16. The acid-agglutination test is of no value in routine dysentery work.

17. The indol reaction is of great value in the differentiation of B. Ambiguus from B. Shiga, but it is of no importance in work upon the mannite-fermenting group.

18. In the early stages of the disease mixed infections are rare.

19. Well marked local manifestations are found post-mortem in the intestines & toxic conditions in other organs including the suprarenals.

20. Dysentery bacilli have been recovered post-mortem from the jejunum, ileum, colon, spleen, & mesenteric glands.

TABLE I.

Showing action of B. Dysenteriae Shigae on Maltose & Saccharose.

No.	Maltose.	Sacchharose.	Indol.	Remarks.
1.	-	-	-	
2	-	-	-	
3	-	-	-	
4	-	-	-	
5	A(8)	-	-	
6	A(11)	-	-	
7	A(7)	-	-	
8	A(7)	-	-	
9	A(1)	-	-	
10	A(12)	AD(17)	-	
11	A(11)	A(12)	-	
12	-	-	-	when first isolated.
	sl.A(15)	sl.A(16)	-	6 months later.
13	-	-	-	when first isolated.
	A(8)	A(16)	-	5 months later
14	-	-	-	when first isolated.
	A(11)	-	-	3 months later.
15	A(14)	-	-	when first isolated.
	A(11)	-	-	4 months later.
16	sl.A(14)	-	-	when first isolated.
	sl.A(1)	A(9)	-	4 months later.
17	-	-	-	when first isolated.
	sl.A(10)	-	-	2 months later.
18	-	-	-	when first isolated.
	A(10)	-	-	2 months later.
19	A(14)	-	-	Both from
19(a)	A(11)	-	-	same case.
20	A(7)	-	-	Both from
20(a)	A(3)	-	-	same case.
21	A(6)	A(7)	-	Both from
21(a)	A(10)	A(11)	-	same case.
21(a)	sl.A(15)	-	-	6 months later.
22	-	-	-	Both from
22(a)	sl.A(7)	-	-	same case.
22(a)	A(9)	-	-	6 months later.

- = no action on carbohydrate or no indol production in 3 to 17 days.

sl.A(10) = slight acid production in 10 days.

D = bleaching of media.

TABLE 2.

showing variations among mannite fermenting dysentery bacilli in their action on maltose & saccharose; in indol production and in their agglutination by specific anti-dysenteric sera.

No.	Maltose.	Saccharose.	Indol.	Agglutination. Y	F	LY
1	-	-	-	1	1+	0.8
2	-	-	-	0.4	0.9	1
3	-	-	-	0.4	0.2	0.6
4	-	-	-	0	1+	0.6
5	-	-	-	0	0.5	0.3
6	-	-	-	0	1	0.3
7	-	-	-	0	0	0.6
8	-	-	+(8)	0	0	1
9	-	-	-	0	0	0.3
10	AD(7)	-	-	0.2	1+	0
11	A(8)	-	-	0.4	0.1	0
12	A(6)	-	-	0	1	1
13	A(10)	-	+	0	1+	0.4
14	A(3)	-	-	0	0.6	0.6
15	A(1)	-	-	0	0.2	0.3
16	A(1)	-	-	0	0.25	0.3
17	A(11)	-	-	0	0.3	0.3
18	-	A(7)	-	0.12	1+	0.9
19	-	A(9)D(13)	-	-	0.1	0.5
20	-	A(9)B(12)	-	0.1	0.2	0.5
21	-	A(5)D(6)	-	0.15	0.15	1+
22	-	A(6)	+	0	-	1+
23	-	AD(6)	-	0	trace	1+
24	-	AD(8)	-	0	1+	0.4
25	-	A(5)D(11)	-	0	0.1	0.8
26	-	A(5)	-	0	0	0.5
27	-	A(7)	-	0	1+	1
28	-	A(3)D(7)	-	0	0.6	0.3
29	-	A(9)	-	0	0.6	0.5
30	-	A(2)	-	0	trace	1+
31	-	A(6)	-	0	1	0.5
32	-	A(10)	-	0	0.6	0.5
33	-	A(10)	-	0	1+	0.5
34	-	A(5)	-	0	1+	0.6
35	-	A(10)	-	0	1+	0.5
36	-	A(8)	-	0	0.4	0.3
37	-	A(6)	-	0	0.4	0.5
38	-	A(2)	+	0	0.25	0.3

TABLE 2. Contd.

No.	Maltose.	Saccharose.	Indol.	Agglutination. Y.	F.	LY.
39	-	A(6)	-	0	1.+	0.5
40	-	A(5)	-	0	1+	0.3
41	-	A(6)	-	0	1+	0.5
42	-	A(3)	-	0.25	1	1
43	-	A(4)	0	0	0	1+
44	-	A(5)	0	0	0	1+
45	-	A(9)	0	0	0	1+
46	-	A(5)	0	0	0	1+
47	-	A(10)	0	0	1+	1+
48	-	A(6)	-(15)	0	0	1+
49	-	A(6)	-(9)+(15)	0	0	1
50	-	A(9)	+	0	0	1
51	-	A(9)	+	0	0	1
52	-	A(3)	-(8)	0	0	1+
53	-	A(7)	+	0	0	1
54	-	A(8)	-(6)	0	0	1+
55	-	A(6)	+	0	0	1+
56	-	A(6)	-	0	0	1+
57	-	A(7)	+	0	0	1
58	A(11)	A(8)	-	0.15	0.5	0
59	AD(10)	AD(6)	+	0.05	-	1+
60	A(5)	A(3)	-	0.2	0.4	0
61	A(7)D(8)	A(6)D(7)	+	0.4	0.1	0
62	A(16)	A(17)	-	0.2	0.4	0
63	A(1)	A(1)	+	0.2	0.12	1+
64	A(14)	A(3)D(5)	+	0.5	0.1	1+
65	sl.A(9)	A(4)	-	0.25	1+	1
66	AD(5)	A(3)D(9)	+	0.2	0.05	1+
67	A(3)	A(11)	-	0.5	1+	1+
68	A(4)D(8)	A(19)	-	0.3	0.4	0.4
69	A(12)	A(2)D(7)	-	0.5	1+	1+
70	A(4)	A(10)	-	0	0.4	0.2
71	A(11)	A(6)	-	0	1	0.6
72	A(8)	A(6)	-	0	1	1
73	A(1)	A(3)	-	0	1	0.5
74	AD(9)	A(2)	+	0	0.05	1+
75	A(3)	A(7)	-	0	0.18	1+
76	A(4)	A(9)	-	0	0.2	1+
77	A(3)	A(7)	-	0	1+	0.6
78	A(3)	A(2)	-	0	0.2	0.25
79	A(1)	A(2)	-	0	0.6	0.5
80	A(3)	A(3)	+	0	0+	1+
81	A(4)	A(4)	+	0	0+	1+
82	sl.A(2)	A(6)	-	0	0	1+

TABLE 2. Contd.

No.	Maltose.	Saccharose.	Indol.	Agglutination. Y.	F.	LY.
83	A(4)	A(8)	-	0	0	0.5
84	A(4)	A(4)	-	0	0	1
85	A(8)	A(5)	-	0	0	1
86	A(6)	A(5)	-	0	0	0.6
87	A(7)	A(7)	+	0	0	0.6
88	A(2)	A(4)D(7)	0	0	0	1
89	AD(1)	A(1)	+	0	-	1+
90	A(9)	AD(11)	+	0	trace	1+
91	A(2)	A(4)D(5)	+	0	-	1+
92	A(3)	A(8)	-	0.07	-	0.5
93	A(7)	A(7)	+	0	0	1+
94	A(8)	A(7)	-	0	0	1+
95	A(4)	A(6)	-	0	0	0.8
96	A(2)	A(5)	-	0	0	1
97	A(2)	A(1)	0	0	0	0.25
98	A(12)	A(8)	-(8)	0	0	1+
99	A(1)	A(9)	0	0	0.07	0.3
100	A(14)	A(10)	-	0.1	0.1	0.3

\+ = indol production positive in three or more days.

\- = { no fermentation of carbohydrate: no indol production in three or more days: or no agglutination by serum at 1/200.

0 = test not carried out.

Sera used:- 'Y' = Royal Army Medical College 'Y' serum having titre for Flexner of 1/3000, & for 'Y' of 1/7000.

'F' = R.A.M.College Flexner serum having titre for Flexner of 1/3000.

'LY' = Lister Institute 'Y' serum having titre for Flexner of 1/1000 & for 'Y' of 1/1500.

Agglutination values are given in decimals representing approximately the 'end point', taking the titre given on the bottle as standard. e.g. 0.5 = agglut. to ½ stand. titre
1+ = " "beyond " "

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TABLE 3.

showing variability in maltose and saccharose fermentation, in indol production and in specific agglutinability of dysentery bacilli of the mannite fermenting group obtained from the same patient at different times, and in the same strains after subcultivation.

No.	Maltose.	Saccharose.	Indol.	Agglutination. Y.	F.	LY.	CB.	Remarks.
101	-	A(13)D(1)	-	0.2	1+	0.5	0	) Both from
101(a)	-	A(13)D(15)	-	0	1+	0	0	) same case.
102	-	A(8)	-	0.5	1+	1+	0	) Both from
102(a)	A(13)D(14)	A(8)	-	0.5	1+	1+	0	) same case.
103	-	AD(F)	-	0	1	1	0	) All three
103(a)	-	AD(10)	-	0	1	1	0	) from same
103(b)	-	A(6)D(7)	-	0	1	1	0	) case.
104	-	A(6)	0	0	0	0.3	0	) Both from
104(a)	A(1)	A(7)	0	0	0	1	0	) same case.
105	AD(12)	A(7) D(12)	+	0.05	0.05	0.8	0	) Both from
105(a)	A(9)	A(3)	+	0.05	0.1	0.5	0	) same case.
106	A(3)	A(10)	-	0.6	0.8	1.	0	) Both from
106(a)	-	A(6)	-	0.6	0.8	1	0	) same case.
107	A(6)	A(6)D(7)	-	0	1+	0.4	0	) Both from
107(a)	A(4)	A(6)D(10)	-	0	1+	0.4	0	) same case.
108	A(3)	A(5)D(6)	+	0	trace	1+	0	) Both from
108(a)	A(3)	A(5)	+	0	"	1+	0	) same case.
109	A(6)	A(3)	-	0	0.25	0.25	0	) Both from
109(a)	-	-	-	0	0.3	0.25	0	) same case.
110(a)	A(6)	AD(9)	+	0	-	-	0	) Both from
110(b)	A(9)	A(8)	+	0	-	0.15	0	) same case.
111(a)	A(2)	-	+	0	-	0.1	0	) Both from
111(b)	A(1)	-	+	0.1	-	0.1	1	) same case.
(a)	A(5)	A(3)	-(10)	0	0.2	0.5	0	) All from
112 (b)	-	A(7)	-(10)	0	0.25	0.6	0	) same plate
(c)	-	A(5)	-(10)	0	0.15	0.3	0	) and treated
(d)	sl(A(19)	A/5	-(10	0	0.2	0.6	0	) alike.

TABLE 3. Contd.

No.	Maltose.	Saccharose.	Indol.	Agglutination. Y.	F.	LY.	CB	Remarks.
(a)	-	A(3)	-(10)	0	0.25	0.6	0	All from
113(b)	-	A(6)	-(10)	0	0.3	0.9	0	same plate
(c)	-	A(7)	-(10)	0	0.25	0.4	0	& treated
(d)	-	A(4)	-(10)	-	0.1	0.6	0	alike.
114(a)	-	-	0	0.5	1	1	0	Both from
(b)	-	-	0	0.5	1	1	0	same plate.
115(a)	-	-	+	0	trace	0.1	0	Both from
(b)	-	-	+	0	0.7	0.1	0	same plate.
116(a)	-	A(3)	-	0	0	1+	0	Both from
(b)	A(16)	A(4)	-	0	0	1+	0	same plate.
110(a)	A(6)	AD(9)	+	0	-	-	0	When isolated.
	-	A(3)	+	0.1	-	0.1	1	49 dys. later
110(b)	A(9)	A(8)	+	0	-	0.15	0	When isolated.
	-	A(5)	+	0.07	trace	trace	0.9	49 dys. later
111(a)	A(2)	-	+	0	-	0.1	0	When isold.
-	A(1)	-	+	0	0.15	0.15	1	49 dys. later
115(a)	-	-	+	0	trace	0.1	0	When isold.
	-	-	+	0.05	"	0.1	1	53 dys. later
115(b)	-	-	+	0	0	.07	0.1	When isold.
	-	-	+	0.07	trace	0.1	1	53 dys. later
116	A(4)	AD(6)	-	0.05	"	0	0	When isold.
	sl.A(1)	A(12)	+	0.15	0.07	1+	0	100 dys. later
117	A(2)	-	+	0.1	-	0.1	0	When isold
	A(3)	-	+	0.4	-	0.4	0	44 dys. later
118	A(2)	-	-	0	-	0.05	0	When isold.
	A(1)	A(1)	+	0.4	-	0.4	0	43 dys later
119	A(4)	-	+	0	0	0.25	0	When isold.
	A(14)	-	+	0.7	-	1	0	22 dys later
120	A(4)	-	+	0.1	-	0.2	0	When isold.
	A(1)	-	+	0.1	-	0.2	1	29 d. later
121	-	A(6)	-	0	0.2	0.1	0	When isold.
	-	A(4)	+	0.08	-	0.1	1	37 d. later.

TABLE 3. Contd.

No.	Maltose.	Saccharose.	Indol	Agglutination. Y.	F.	LY.	CB	Remarks.
122	- AD(14)	AD(1) AD(3)	+ +	0.25 0.25	- -	1+ 1+	0 0	When isolated. 20 dys later.
123	- -	A(1) -	+ +	0 0.1	0.1 -	0.25 0.07	0 1	When isolated 28 days later.
124	- 0	- 0	0 0	0 0	0.07 -	0.5 1	0 0	When isolated. 46 days later.
125	- A(1)	A(8) A(14)	- -	0 0.1	0.07 0.15	0.25 0.3	0 0	When isolated. 23 days later.
126	A(4) A(7)	A(6) A(5)	- -	0 0.5	0 1	0.25 0.8	0 0	When isolated. 26 days later.

Serum 'CB' is polyvalent Flexner-Y serum prepared at the R.A.M.College from Flexner-Y, Kruse'E' and two inagglutinable strains of mannite fermenting dysentery bacilli and having a titre of 1/4000.

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TABLE 4.

showing a few types of B. Ambiguus (Andrewes) which resembles B. Dysenteriae Shigae biochemically but differs from the true Shiga bacillus in failing to agglutinate with specific Shiga antisera, or with the patients' own sera; in the production of indol in peptone water; and as a rule in acid- agglutination (Michaelis).

No.	Maltose.	Saccharose.	Indol.	Acid-Agglutination. Tube. 1.	2	3	4	5	6
1	-	-	+	-	-	-	-	+	+
2	-	-	+	-	-	-	-	+	+
3	-	-	+	-	-	-	-	+	+
4	A(4)	A(5)	+	-	-	+	+	+	+
5	A(11)	-	+	-	-	-	-	+	+
6	A(2)	-	+	-	-	-	-	+	+
7	AD(1)	-	+	-	-	-	-	-	-
8	A(9)	-	+	-	-	-	-	-	-
9	A(4)	-	-(thrice)	-	+	+	+	+	+
10 (motile)	-	-	-(7)	-	-	-	-	+	+

TABLE 5.

showing a few types of B. Dispar & B. Alkalescens (Andrewes) which in their early fermentations resemble members of the mannite fermenting group of dysentery bacilli but which differ therefrom in producing late acid in lactose (Dispar) or in dulcite (Alkalescens).

No.	Maltose.	Saccharose.	Lactose.	Dulcite.	Indol.	Acid-Agglutination I	2	3	4	5	6
1	-	-	A(6)	-	-	-	-	-	+	+	+
2	-	-	A(4)	-	+	-	-	-	+	+	+
3	A(3)	A(5)	A(5)	-	-	+	+	+	+	+	+
4	A(2)	A(3)	A(3)	-	+	-	-	+	+	+	+
5	A(1)	A(2)	A(2)	-	+	-	+	+	+	+	+
6	A(1)	A(5)	A(5)	-	+	-	-	+	+	+	+
7	A(2)	A(10)	A(10)	-	-	+	+	+	+	+	+
8	A(2)	-	A(9)	-	+	-	-	-	-	+	+
9	A(2)	A(1)	A(7)	-	+	-	+	+	+	+	+
10	A(1)	-	A(4)	-	+	-	-	-	-	+	+
11	A(8)	-	-	A(7)	-	-	-	-	+	+	+
12	A(7)	-	-	A(6)	-	-	-	-	-	+	+
13	A(8)	-	-	A(8)	-	-	-	-	-	+	+
14	A(4)	-	-	A(8)	-	-	-	-	-	-	+
15	A(1)	-	-	A(12)	-	-	-	-	-	-	+

TABLE 6.

showing positive agglutinations by patients' sera in cases of proved dysentery, employing

(a) emulsion of patients' own organism:
(b) " " one or more strains isolated during the epidemic.
(c) Dreyer's standard dysentery emulsions:
(d) Positives obtained by any or all of the above methods.

As the total numbers are small the results are grouped at the end of the table into periods of (4---6), (7---10), (11---14), & (15---30) days respectively.
The numerator of the fractions in each column is the number of positives obtained under that heading, the denominator the total number of cases tested.

Day of disease.	(a) Patients' strain.	One or more current strains.	(c) Dreyers emulsions.	(d) Any or all of preceding
4	0/1 = 0%	0/5 = 0%	2/4 = 50%	2/5 = 40%
5	1/4 = 25%	2/10 = 20%	5/9 = 55%	6/10 = 60%
6	5/9 = 55%	4/13 = 30.5%	7/10 = 70%	9/13 = 69%
7	6/9 = 66%	6/13 = 46%	7/9 = 77%	11/13 = 84%
8	8/13 = 61.5%	11/19 = 58%	9/15 = 60%	17/20 = 85%
9	8/12 = 66%	8/14 = 57%	7/11 = 63%	11/14 = 78.5%
10	6/9 = 66%	7/16 = 44%	10/13 = 77%	13/17 = 77%
11	3/4 = 75%	2/5 = 40%	3/5 = 60%	3/5 = 60%
12	4/8 = 50%	4/11 = 36%	6/10 = 60%	7/12 = 58%
13	2/2 = 100%	1/2 = 50%	2/2 = 100%	2/2 = 100%
14	5/7 = 71%	8/11 = 73%	2/7 = 29%	9/13 = 70%
(4--6)	6/14 = 43%	6/28 = 21%	14/23 = 62%	17/28 = 60.5%
(7--10)	28/43 = 65%	32/62 = 51.6%	33/48 = 68%	52/64 = 81%
(11--14)	13/20 = 65%	12/26 = 46%	13/24 = 54%	17/28 = 55%
(15--30)	5/12 = 42%	12/23 = 52%	7/15 = 47%	17/24 = 71%
Total (4--30)	52/89 = 58%	62/139 = 44.6%	67/110 = 61%	103/144 = 71.6%

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